SOFT CURD MILK PRODUCED WITH PANCREATIC CONCENTRATE

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The value of soft curd milk in human nutrition has been discussed at length and there have been many and varied attempts and systems of softening the curd of cow's milk. It is generally known that a larger proportion of cow's milk is digested in the stomach of calves in comparison to the amount of human milk digested in the stomach of infants, and it is believed that in order to keep this phenomenon constant these milks are so constituted that this will be possible. The softening of the curd of cow's milk for human consumption is an attempt to make it more nearly like that of human milk with respect to its digestion in infants and adults.

Scales (1) and Carpenter (16) describe three kinds of casein normally present in milk and offer the theory that the change in ratio of these three types of casein may have something to do with the hardness or softness of milk curds. That the digestion of milk is facilitated with the use of soft curd milk is demonstrated by Doan and Welch (2, 3), Espe and Dye (4), and Hill (5). Hill has described the following groups of infants that benefit from the use of soft curd milk: Newly born bottle fed babies, persistent vomiters of whey and leathery curds, colicky babies, the ne'er-do-well group that does not benefit from boiled or sweetened milk, and celiacs and chronic indigestion group and the group that suffers from infantile eczema. Espe and Dye studied the character and activity of the curd in Pavloff pouches of dogs and were able to show that soft curd milk digested more readily than hard curd milk and that the casein content was the factor which affected the nature of the curd more than any of the other milk constituents. Other investigators who discovered that the percentage of casein was very closely related to the type of curd formed in the digestive processes were Scales (1) and The Council on Foods (6), and these investigators generally agree that natural soft curd milk is likewise a low casein milk.

Berry (7) proved that boiling actually lowered the curd tension of milk and also discovered that colostrum was a very hard curd milk. He found that viscolization pressures of 3000 to 5000 pounds were necessary to render hard curd milk soft and this evidence was supported by Theophilus, Hansen and Spencer (8) who decreased the curd tension of milk by homogenization in a single and two-stage homogenizer. Otting and Quilligan (9) described a method of softening the curd by using zeolite sand, during which part of the calcium is removed from the milk thus inhibiting the activity of coagulating enzymes. The Council on Foods (6) also brings out that milk curd may

Received for publication February 3, 1938.

be softened by dilution with water, the addition of acids and alkalies and the addition of various cereal extracts.

Lahrmann (10) in making a substitute for mother's milk used digestive ferments. He very nearly completely digested the casein and albumen and added water, sugar, cream, potassium carbonate and phosphoric acid. Von Dungern (11) produced a soft curd milk by coagulating the milk with rennet and then dispersed the curd particles by a mechanical means. Backaus (12) showed that by the addition of alkalies and trypsin to milk in combination with cream and lactose he was able to produce a soft curd milk. Thew (13) produced a soft curd milk by peptonization accompanied by the addition of sodium bicarbonate and condensation. Turney (14) also produced a soft curd milk by the use of a curdling enzyme and concentration of the milk by draining off the whey.

PLAN OF EXPERIMENT

The processes for producing soft curd milk described above have certain disadvantages in that they require special equipment and are in general lengthy procedures. The severe enzyme treatment as recommended by Lahrmann results in the formation of bitter proteoses, peptones and amino acids. Our problem was one of producing a soft curd milk, at a reasonable expense and by a method which would fit into the ordinary dairy plant, without taking away any of the natural nutritive value or minerals of the milk.

The use of digestive enzymes presented itself favorably, in view of the fact that small amounts could be used and there was a possibility that a method could be found for using them in milk plant operations. Preliminary experiments showed that the use of specially prepared (high tryptic, low diastatic) pancreatic enzymes in dilutions of 1–6500 reduced the curd tension considerably but the reaction between the milk protein and the enzyme continued upon the storing of the milk and produced a bitter flavor when the enzyme was added after pasteurization. This brought out the necessity for determining how the enzyme should be inactivated and what the fate of the enzyme plus milk would be under pasteurization conditions.

It was determined that milk could be pasteurized in the presence of pancreatin if the dilution of enzyme with milk was high enough. The inactivation of pancreatin was determined by making dilutions of enzyme with milk and heating the milk to temperatures varying from 62.5 to 73.0° C. The curd softening process was studied from the standpoint of the dilution factor, temperature and time of incubation, type of enzyme used, the storage properties of the softened milk, the effect on the calcium-phosphorus, calcium-magnesium, calcium-protein ratios, formol titration, dialyzability of inorganic material, and the in vivo reaction of the softened milk in c[illegible] stomachs.

METHOD

The method which was used in the curd softening process was devised so that it could be applied with either the flash or the holder method of pasteurization. A typical batch would be prepared by weighing out enough of the pancreatic concentrate to make a dilution of 1–10,000 when incorporated into the milk. This finely ground powder is diluted with enough water so that there are no large particles remaining on the surface and this in turn is poured into the milk to be softened at a temperature of 43° C. The milk is then allowed to incubate for 15 minutes, which is followed by the regular pasteurization process. The temperature used in the flash method was 73.0° C. and the temperature used in the holder was 62.5° C.

The curd tension of the milk was measured by the method of Hill (15) and although this method was found to have various sources of error, each curd tension determination consisted of running four samples and by taking the average of these consistently accurate results were obtained. The data compiled in Table 2 were founded upon the methods recommended by the Association of Official Agricultural Chemists, with the exception of the Walker method which was used in the formol titration.

RESULTS

The results of the inactivation experiments showed that if the milk plus enzyme were held at a temperature of 73° C. for 15 seconds 90 to 95 per cent of the enzyme was inactivated, and if the milk plus enzyme were held at 62.5° C. for ½ hour similar results were obtained. The pasteurization of milk in the presence of pancreatin was possible with dilutions as low as 1–5000.

The data incorporated in Table 1 show that milk curd tension could be lowered consistently to an average of 21.7 grams of tension when the flash and holder method of pasteurization are considered jointly. The decrease in curd tension was accomplished in a variety of ways and with respect to the dilutions used favorable results were obtained with values ranging from 1–6500 to 1–50,000. When the holder method of pasteurization is employed a higher dilution of enzyme can be used. The flash type of pasteurization was used best in conjunction with a 15-minute incubation period at a temperature of 42° C. The time and temperature of incubation required for pasteurization by the holder method was found to have little significance on the amount of reduction in curd tension and this was varied from 24 hours at 7° C. to 15 minutes at 43° C. The average curd tension of the raw milk was approximately 50 grams. Upon storing milk softened by this method it was found that the curd tension decreased an average of 5.6 grams in 72 hours.

The curd tension of milk could be reduced only 5 or 6 grams by the use of diastase, when the dilution of diastase was 1–250 and 1–500. These ex

TABLE 1

Data of soft curd milk produced with variations in dilutions, incubation, and pasteurization

No. of samples	Enzyme used	Dilution in milk	Temp. of incubation °C.	Time of incubation	Temp. of inactivation °C.	Average tension of control	Average tension of softened milk	Average tension after 72 hours
24	Pancreatin	1–6500	36°	15 min.	74° Flash	60 grams	25 grams	23 grams
15	"	1–6500	31°	15 "	76° Flash	50 "	22 "	
15	"	1–10,000	43°	15 "	76° 6 min.	55 "	22 "	
20	"	1–10,000	42°	25 "	76° Flash	50 "	28 "	15 "
15	"	1–20,000	42°	30 "	73° Flash	40 "	28 "	18 "
15	"	1–30,000	42°	30 "	73° Flash	36 "	22 "	26 "
30	"	1–20,000	7°	24 hrs.	62.5° 30 min.	40 "	26 "	20 "
30	"	1–30,000	7°	24 "	62.5° 30 min.	42 "	28 "	24 "
20	"	1–20,000	none	none	62.5° 30 min.	52 "	30 "	21 "
25	"	1–20,000	15°	6 hrs.	62.5° 30 min.	40 "	30 "	24 "
16	"	1–15,000	none	none	62.5° 30 min.	38 "	26 "	24 "
28	"	1–40,000	7°	24 hrs.	62.5° 30 min.	42 "	30 "	22 "
28	"	1–50,000	7°	24 "	62.5° 30 min.	46 "	30 "	24 "

Results, All Data

The 172 + ΔW records give, $DN = .266FCM + .0134W^{.96} + 1.86\Delta W$.
The 81 − ΔW records give, $DN = .293FCM + .1976W^{.65} + 1.15\Delta W$.
Both groups together give, $DN = .275FCM + .0161W^{.93} + 1.63\Delta W$.

The equation for both groups together is derived from the data of Table 1, in which the figures in the DN″ column are equal to 1000K of equation (1) divided by W of Table 1. That is, the + ΔW and − ΔW groups are allowed to keep their identity, rather than to mix + ΔW and − ΔW records in the same group. This may or may not be necessary. It is done with the thought that it may give more representative values to the K's of equations (1).

If the above result for both groups is taken as a summary of the 253 records, it appears that working maintenance is proportional to the .93 power of live weight. What does this mean from the standpoint of a practical feeding standard for cows in milk? The DN″ column of Table 1 gives, as indicated, the nutrients for working maintenance, K of equation (1), per day per 1000 pounds live weight, for each of the 25 groups of 10 records. In Figure 1 working maintenance per 1000 pounds live weight is plotted against live weight. The correlation between the two is $r = -.07 \pm .15$. The regression equation is $1000DN''/W = 9.67 - (.0007 \pm .0014)W$.

As thus determined, working maintenance per unit live weight is quite variable, as may be seen in Figure 1. There is a tendency for it to decrease

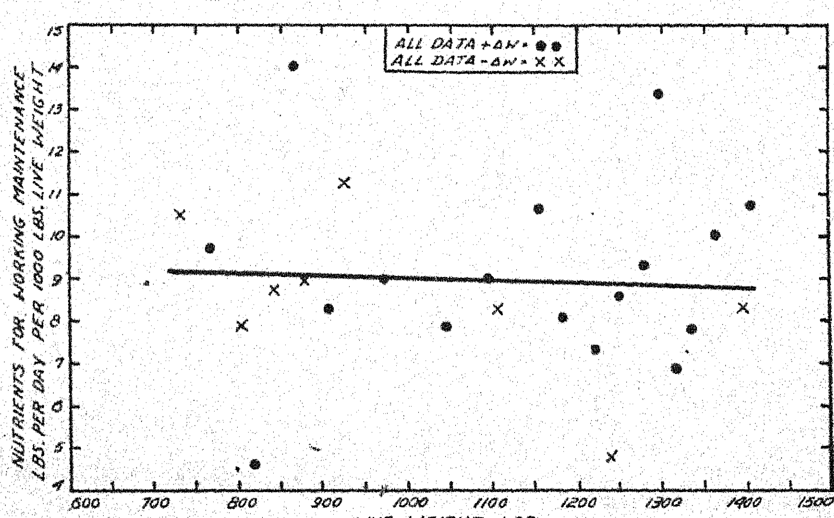

FIG. 1. Relation of working maintenance per unit live weight to live weight, from Table 1.

with live weight, but this tendency is not statistically or practically significant.

Minnesota and Cornell Data

The present method of analysis requires a considerable number of records to be justifiable. It is permissible, however, to apply it to the Minnesota data (n = 98) and to the Cornell data (n = 103). The same general plan is followed, using groups of successive 5's. Tables 2 and 3 give the results for the groups of 5. In Figure 2 working maintenance per 1000 pounds live weight is plotted against live weight for the Minnesota and Cornell data separately.

TABLE 2

Digestible nutrients apportioned to lactation, working maintenance and live-weight gain
Records of Guernsey, Holstein and Jersey cows from Minnesota Experiment Station, in groups of 5.
(See footnote, page 585, for explanation of symbols.)

Group No.	Sign of ΔW	n	Live-weight Limits, lbs.	W	DN′ = aFCM a	DN″ = bW 1000 b	DN‴ = dΔW d
1	−	5	634– 735	698	.1910	10.87	−8.13
2	+	4	735– 765	753	.3452	8.27	2.94
3	−	5	752– 783	765	.3490	7.59	4.17
4	+	5	766– 789	780	.4353	6.25	−10.15
5	−	5	792– 809	800	.2163	9.15	−1.64
6	−	10*	811– 884	827	.3361	7.11	3.39
7	+	15*	790– 887	840	.0544	16.76	−4.31
8	−	5	845– 858	853	.3640	6.82	1.12
9	−	5	859– 877	869	.5267	2.89	10.82
10	−	5	887– 898	890	.3266	9.46	8.75
11	−	5	902– 923	912	.2897	8.83	1.07
12	+	5	890– 976	933	.2840	8.44	12.71
13	−	5	925– 978	944	.2578	9.56	−10.94
14	+	5	978–1071	1024	.5004	6.35	−14.96
15	−	5	985–1273	1073	.3109	8.20	.61
16	+	9*	1072–1315	1177	.1999	11.53	−2.04

* These combinations were made to get rid of negative values of b, appearing in the groups of 5.

The correlations between working maintenance per unit live weight and live weight are, Minnesota, r = .06 ± .17, and Cornell, r = .03 ± .15. The regression equations are, Minnesota, $1000DN''/W = 7.38 + (.0014 \pm .0042)W$, and, Cornell, $1000\ DN''/W = 7.95 + (.0009 \pm .0043)W$. Both the Minnesota and Cornell experiments show a tendency for working maintenance per unit live weight to increase with live weight, but in neither case is this tendency statistically or practically significant.[3]

[3] It will be apparent that correlating K/W with W from equation (1) is essentially a test of the postulate that working maintenance is proportional to live weight. In a similar way, to test the postulate that working maintenance is proportional to physiologic weight, which is proportional to the .73 power of live weight, as contended by Brody (2), we would correlate $K/W^{.73}$ with $W^{.73}$. This gives, from the 25 groups of Table 1, all

TABLE 3

Digestible nutrients apportioned to lactation, working maintenance and live-weight gain
Records of Holstein cows from Cornell Experiment Station, in groups of 5.
(See footnote, page 585, for explanation of symbols.)

Group No.	Sign of ΔW*	n	Live-weight Limits, lbs.	W	$DN' = aFCM$ a	$DN'' = bW$ 1000 b	$DN''' = d\Delta W$ d
1	+	5	1081–1159	1126	.2815	9.05	−1.02
2	+	5	1163–1181	1171	.2607	10.19	−1.02
3	−	5	1155–1195	1173	.3047	8.30	−1.14
4	+	5	1184–1196	1191	.2460	9.63	2.61
5	+	5	1203–1220	1213	.2691	8.27	3.54
6	−	5	1203–1238	1224	.4188	4.48	−3.56
7	+	5	1220–1232	1226	.3925	5.62	1.28
8	+	5	1239–1251	1245	.0865	13.55	−.30
9	+	5	1266–1272	1270	.2395	9.86	−.74
10	−	5	1251–1331	1272	.3222	7.14	−.09
11	+	5	1272–1285	1278	.2358	8.85	3.69
12	+	5	1286–1296	1291	.2143	10.19	−.64
13	+	5	1297–1305	1300	.0457	15.11	−1.13
14	+	5	1306–1323	1314	.2564	9.21	−.75
15	+	5	1323–1333	1328	.2616	8.47	2.05
16**	+	5	1337–1344	1340	−.2435	21.87	−6.98
17	−	5	1332–1379	1355	.1959	10.04	3.86
18	+	5	1346–1375	1364	.2260	8.85	1.76
19	+	5	1382–1389	1386	.2183	9.11	1.76
20	+	4	1398–1453	1423	.3419	6.77	−2.09
21	−	4	1394–1500	1454	.2124	9.25	.91

* There are here 79 + ΔW's and 24 − ΔW's, instead of 80 and 23, respectively, in the previous paper (1). This is due to working directly with Cornell Bulletins 540 and 578, thus eliminating several errors in Missouri Research Bulletin 239. These errors are still present in Table 1.

** This group is excluded in figure 2 and in the computation of correlation, etc., on account of the negative value of a. It was found impossible to get rid of this negative value by including an adjoining group, as in Table 2.

data, $r = .17 \pm .13$; from the 16 groups of Table 2, Minnesota data, $r = .17 \pm .17$; from the 20 groups of Table 3, Cornell data $r = .10 \pm .15$. From the 36 groups of Tables 2 and 3, Minnesota and Cornell data together, $r = .29 \pm .10$, a result which borders on statistically significant evidence that the $W^{.73}$ postulate is not supported by the experimental results. Regardless of statistical significance, indicated by the "probable errors," the best estimate from the Minnesota and Cornell data, together or separately, is that working maintenance per unit live weight tends to increase with live weight. These two sets of data are given emphasis because they agree with each other (see Figure 2), and each in itself possesses a homogeneity of experimental conditions which may be lacking when the other 52 records from miscellaneous sources are included.

A point of interest is the relation between live weight and nutrients for lactation per pound of FCM, that is: [illegible]orrelation between W and a of Tables 1, 2 and 3. The coefficients are, from the 25 [illegible] of Table 1, all data, $r = -.20 \pm .13$; from the 16 groups of Table 2, Minnesota data, [illegible] $\pm .17$; from the 20 groups of Table 3, Cornell data, $r = -.22 \pm .15$.

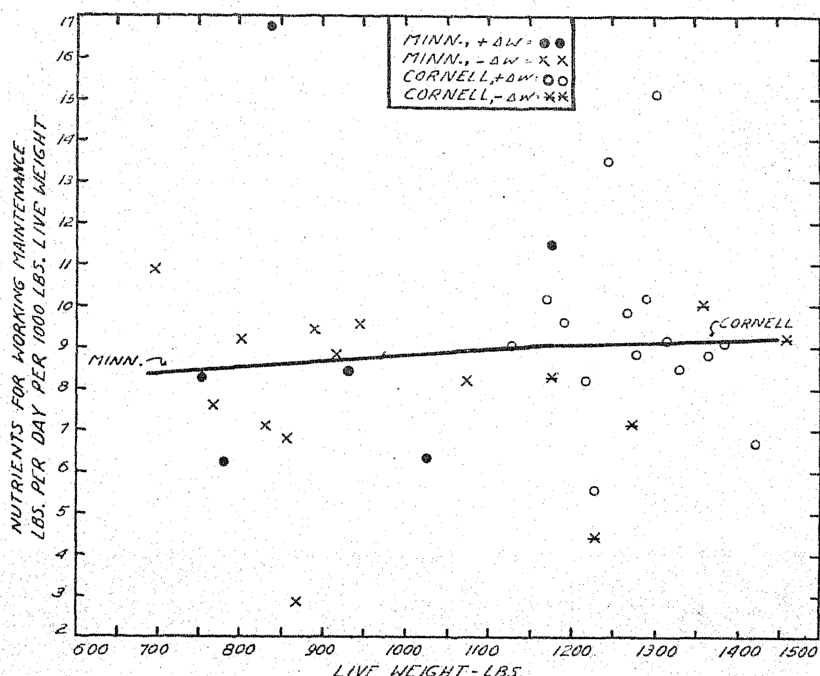

FIG. 2. Relation of working maintenance per unit live weight to live weight, from Tables 2 and 3.

DISCUSSION

It is amazing that, under the present treatment, the Cornell data show working maintenance to be proportional to live weight (or to a power of live weight slightly greater than unity), while under the former treatment (1) the same data showed working maintenance to be proportional to the .15 power of live weight, or substantially independent of live weight. In the former treatment the problem of nutrients for gain in weight, $DN''' = d\Delta W$, was summarily disposed of by assigning values to d according to the proposal of Knott, Hodgson and Ellington (3), that is, $d = 3.53$ for $+\Delta W$'s and $d = 2.73$ for $-\Delta W$'s. Could this summary procedure be responsible for the great difference in result?

For answer, the Cornell data have been reworked under the former plan but including ΔW in the normal equations, thus allowing d to find its own value from the observations themselves. Following is a comparison of the former results (1), $\Sigma D^2/(n-2)$, as against the inclusion of ΔW, $\Sigma D^2/(n-3)$, using $(n-3)$ since we now have 3 constants in the equation as fitted:

Trial value of c	= 0	.15	.45	.73	1.00	1.27	2.00
$\Sigma D^2/(n-2)$, 80 + ΔW's	= .832	.818	.836	.907	1.017	1.159	1.628
$\Sigma D^2/(n-3)$, 80 + ΔW's	= .964	.637	.318	.252	.417	1.154	1.824
$\Sigma D^2/(n-2)$, 23 − ΔW's	= .442	.440	.548	.781	1.102	1.481	2.501
$\Sigma D^2/(n-3)$, 23 − ΔW's	= .356	.364	.492	.743	1.082	1.474	2.513

Inclusion of ΔW in the normal equations makes a large difference in the $+\Delta W$ records, shifting c of equation (2) from .15 to .6 (that is, between .45 and .73). Inclusion of ΔW makes little difference in the $-\Delta W$ records, shifting c from .15 to zero, or slightly less. Evidently the treatment of ΔW in the previous paper does not explain the difference in result as compared with the present paper. In equation (1) K becomes a sort of average value of working maintenance (although including all items other than FCM and ΔW) for the group. It seems worth while to apply the trial-value-of-c method of fitting equation (2) to the average DN, FCM, W and ΔW values of the groups in Table 3. This leads to the result, $c = .15$, that is, not different than previously obtained (1) from the individual records. The trial-value-of-c method amounts to a (clumsy) simultaneous solution for a, b, c and d of equation (2) and it is hard to see why it should not give right results in solving equation (2). However, since in practice it so frequently leads to nonsensical results, it should be discarded in favor of the present method of solving equation (2) through equation (1), where suitable observations are available.

Suitability of the observations depends not only on a sufficiency with respect to numbers, but also on adequacy with respect to design of the experiments. The experiments here utilized were not designed to determine the amount of nutrients used for lactation, on the one hand, and for maintenance, on the other. Thus, a major problem has been to learn the effect of varying proportions of protein in the ration, and there is the possibility that these variations may impair the value of the data for the purpose here used. In view of the great practical and theoretical importance of knowing the amount of nutrients required for lactation and the amount required for working maintenance it would be desirable to carry out experiments[4] designed for the purpose.

The Minnesota and Cornell feeding trials here utilized were largely guided by a standard assigning nutrients for working maintenance as proportional to live weight. Can this be responsible for the outcome pictured in Figure 2, indicating that working maintenance is proportional to live weight? Evidently not, at least we shall see in a later paper (to appear in the October issue of this Journal) that the direct proportionality holds in a

[4] The problem and its solution by the partition-equation method have been beautifully presented by Brody and Cunningham (4). A pedometer record of distance of travel and a record of time lying and standing would be valuable additions to the record of live weight, in the working maintenance problem. A fault of unknown influence in the present treatment is the assumption that live weight follows a strictly linear course from start to finish of the trial, whereas it is known that live weight normally follows a decidedly curvilinear course through the lactation period. That portion of the live-weight curve which is substantially horizontal should be especially suited to the equation method of evaluating the nutrient requirements for lactation and maintenance. Any long trial could well be broken up into short periods to give segments of increasing, decreasing and stationary live weights.

large body of Danish records, although the cows were fed to a working maintenance standard approximately proportional to the 2/3 power of live weight (or, substantially, in units of this paper, $DN'' = .0645\ W^{2/3}$).

The theory that maintenance is proportional to the 2/3 power of live weight has been a favorite for the reason that surface area and consequently amount of heat loss, vary as the 2/3 power of weight. An inactive dry cow may have to expend energy to keep warm, and to that extent idle maintenance may vary directly with $W^{2/3}$. An active milking cow may have to expend energy to keep cool, and to that extent working maintenance may vary inversely (instead of directly) with $W^{2/3}$. Working maintenance bears a very different relation to live weight than does idle maintenance, or especially, "basal" metabolism. We are here concerned with working maintenance of milking dairy cows, and this can be determined only under conditions of work in milk production.

CONCLUSION

It is concluded from the above results that for cows of the Guernsey, Holstein and Jersey breeds, under conditions of the experiments, a proper feeding standard is $DN = .275FCM + .009W$, where DN is pounds of digestible nutrients per day, FCM is milk-energy yield in terms of pounds of 4 per cent milk per day, and W is live weight in pounds.

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ABSTRACTS OF LITERATURE

BACTERIOLOGY

372. **How Sterilizing Agents Act on Bacteria.** I. L. BALDWIN, Univ. of Wisconsin, Madison, Wisconsin. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 88, 1937.

Among micro-organisms the power to reproduce is commonly accepted as the single criterion of life or death. Death of micro-organisms is usually caused by some interference with one or more of the three basic chemical equilibria on which life depends. These are the oxidation reduction equilibrium from which the energy for life processes is derived; the hydrolytic-polymerization equilibrium which is responsible for the building up and tearing apart of certain complex constituents of the cell; and the acid-base equilibrium which serves as a regulator responsible for the building up and tearing apart of certain complex constituents of the cell.

It seems probable that the lethal action of increased acidity or alkalinity upon bacteria is largely due to an increase in the rate of hydrolysis with consequent destruction of protoplasmic constituents. The action of chlorine and hypochlorites is due partially to oxidizing action and partially to their tendency to unite with protoplasmic constituents of the bacterial cell. Destructive forces are the removal of water by drying or the addition of sugar or salt. The lethal action of heat is more effective if moist or if the medium is acid or alkaline and the effect seems to be due to a combination of hydrolysis and coagulation. E.F.G.

373. **Spoilage of Cream at Low Temperatures.** J. A. ANDERSON, Department of Bacteriology, Rutgers University. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 19, 1937.

A new bacterium for which the name *Bacterium lipidis* is proposed exhibits powerful fat splitting action, weak action on protein, and none on sugars growing rapidly at refrigeration temperatures. A sharp throat irritation results from swallowing cream containing the organism and this is thought to be due to liberation of caproic, iso-caproic, and caprylic acids from the milk fat. Spoilage of cream at low temperature is due mainly to hydrolysis of fat and protein which accounts for the rancid and bitter flavors. E.F.G.

374. **A Further Report on Tabulations of Counts Using Proposed Changes in Medium and Temperature of Incubation of Milk Samples.** ERNEST KELLY, Chief, Division of Market Milk Investigations, Bureau of Dairy Industry, U. S. D. A., Washington, D. C. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 25, 1937.

Tables show that standard agar at 32° F. gives more uniform results between plants than tryptone agar at either 37° C. or 32° C. Grade A pasteurized milk seemed to be one of the few exceptions to this. There was greater variation in the results from different laboratories on the same sample of milk with the same medium than there was between the results in the same laboratory using different media and temperatures. It would seem that laboratory procedure needs to be standardized and that greater care to control conditions be exercised if satisfactory results are to be obtained. E.F.G.

375. Dairy Bacteriology. BERNARD W. HAMMER. 2nd Ed., 1938, Wiley, 482 pp., price $5.00.

Dr. Hammer has brought this book up to date by including in the second edition the main facts which have been brought out by research workers during the 10 years since the first edition was published. The book is broad in scope as evidenced by the following list of headings of the 15 chapters:

Bacterial counts of milk; milk fermentations; contamination of milk and cream and its control; growth of organisms in milk and cream; body cells in milk; spread of diseases through milk and its derivatives; preservation of milk and cream; milk enzymes; bacteriology of evaporated, sweetened condensed and dry milk; bacteriology of ice cream; bacteriology of butter cultures; bacteriology of fermented milk preparations; bacteriology of butter; bacteriology of cheese; tests for the general quality of milk and cream.

Dr. Hammer's broad experience in practically all lines of dairy bacteriology and his ability to write clearly on difficult subjects has resulted in a book which is outstanding. M.W.Y.

376. Bacterium in Milk. HERMANN OESER, Pr. Forsch. F. Milchwirtschaft in Kiel. Zentr. Bact. 2, 96, p. 287, 1937.

The problem was to reveal which were the principal representatives of the *Bacterium coli aerogenes* group in raw market milk. The enrichments from the different media were plated on Endofuchsin agar and analyzed primarily after the technique used in German medical laboratories. Furthermore, the behavior in litmus milk, the gas formation in skimmilk at

	Indol	Meth. Red	V.–P.	Citr.	Nr. of strains
1	+	+	–	–	56
2	+	+	–	+	7
3	–	+	–	–	26
4	–	+	–	+	18
5	+	+	+	–	1
6	+	+	+	+	26
7	–	+	+	+	22
8	–	–	+	+	8

30° C., the ability to use citric acid as a sole source of carbon have been determined. The so-called reaction combinations with the known four differential tests gave results as shown in the accompanying table: Some of the combinations found by Ruchhoft *et al.* and Demeter and Sauer could not be detected. There was a remarkable constancy of the Indol and the citrate test and a more or less noticeable variability of the M. R. and V.-P. test. The gas test in skimmilk proved to be a valuable means for differentiation: typical *B. coli* strains produce only a few cc., typical *B. aerogenes* and very many intermediates, however, relatively high amounts of gas. All tests made have been summarized and there were found 25 combinations of theoretically 128 possibilities with 164 strains. Finally the author tried to put the 164 strains into the system of Bergey with the result that he got 12 subgroups. He did not encounter the 7 Escherichia species and 4 Aerobacter species of Bergey. *E. Aerogenes* does not belong to the E. A. group at all and the species *E. acidi lactici* and *E. anindolica* are to be discarded.

K.J.D.

BUTTER

377. How to Determine the Keeping Quality of Butter. C. H. Parsons, Swift and Company, Chicago, Illinois. Nat. Butter and Cheese J. *29*, 7, p. 6, April 10, 1938.

Creameries need a simple test to indicate the quality which butter will have after it has passed through the regular trade channels. A test was developed which has been use for practically five years on thousands of samples of butter. This test consists of holding wrapped, printed butter which has been judged for quality for fourteen days at a temperature of 60° F. At the end of this period of time this butter is again judged for quality. The difference in score indicates the deterioration which the butter has undergone during the test. The butter is always tempered at 45 to 50° F. before judging. Careful control of temperatures of incubation is necessary. Incubation temperatures of 68 to 70° F. for a period of eight days gives approximately the same result as holding for fourteen days at 60° F. Oiling-off of the product may occur at the higher temperatures. If this occurs the test is practically valueless.

W.V.P.

378. How Should Cream be Held at the Creamery? C. C. Totman, S. Dakota State College, Brookings, S. Dak. Nat. Butter and Cheese J. *29*, 8, p. 34, April 25, 1938.

Cream of No. 1 grade or better was divided into three lots and subjected to different treatments. Lot 1 was neutralized to .25 per cent acidity and pasteurized at 145° F. for 30 minutes, cooled and held in the cream vat for 4 to 15 hours before churning. Holding temperatures were 47 to 56° F. Lot No. 2 received essentially the same treatment except that it was stored

in cans for 40 to 44 hours at temperatures varying between 35 to 45° F. Lot No. 3 was held in cans for 40 to 44 hours at temperatures of 35 to 45° F. and was then neutralized and pasteurized in the manner described. Cream from Lot 1 produced butter of lower quality. The decline in scores of butter from this lot was quite noticeable during the last three months of storage. There seemed to be a slight advantage in holding cream raw under the conditions of these experiments. It is suggested that the effects of neutralizer, metallic salts and heat may be responsible for changes in the flavor of the butterfat in cream held for long periods; or that low acidity in neutralized and pasteurized cream during the holding period might favor the development of proteolytic and lipolytic bacteria. W.V.P.

Other abstracts of interest are numbers 373, 432, 447 and 459.

BUTTERMILK

379. How to Make Flake Buttermilk by Spraying Fat into Cultured Skim Milk. E. H. PARFITT. Milk Plant Mo. *27*, 3, p. 27, March, 1938.

The author presents the details of the Vogt method of making flake buttermilk by spraying liquid fat into cultured buttermilk. A comparative body and flavor study of (a) churned-cream buttermilk, (b) churned-flake buttermilk, and (c) Vogt-method buttermilk showed that the body of the churned-cream buttermilk was free from lumps and poured like sweet milk. The other two buttermilks possessed rather heavy bodies. The churned-cream buttermilk flavor was preferred by those accustomed to the "old-fashioned" buttermilk but the flavors of all three types were maintained splendidly for five days. G.M.T.

CHEESE

380. A Study of Inexpensive Pasteurizing Units for Cheese Factories. WALTER V. PRICE and LEO GERMAINE. Univ. of Wisconsin, Madison, Wis. Nat. Butter and Cheese J. *29*, 7, p. 14, April 10, 1938.

Two relatively inexpensive types of pasteurizing equipment which are suitable for use in cheese factories receiving less than 10,000 pounds of milk per day are described. The bacterial destruction efficiency of these two types of equipment were tested by the plate count method. Scores are shown for cheese made from raw milk and from identical milk pasteurized by one or the other of these two types of equipment. Both methods of pasteurizing were sufficiently effective bacteriologically to improve the quality of the cheese. W.V.P.

381. Influence of Manufacturing Methods on Acidity of Brick Cheese. S. W. SPICER and WALTER V. PRICE, Univ. of Wisconsin, Madison, Wis. Nat. Butter and Cheese J. *29*, 10, p. 18, May 25, 1938.

When brick cheese was made from pasteurized milk inoculated with commercial type *S. lactis* starter it was found that the amount of starter, the ripening period before adding the rennet, the temperature of heating, and the time of dipping the curd must be carefully controlled to produce sweet cheese of desirable quality. A development of .02 per cent titratable acidity in the whey before dipping when dipping occurred 2½ hours after setting seemed to provide a correct rate of acid development for the remainder of the process. Heating temperatures of 104° F. in conjunction with this acid development produced a pH at three days after making of approximately 5.1 with a moisture content of 38 per cent at the time of paraffining. Cheese which satisfied these characteristics was sweet and of desirable quality. W.V.P.

382. The Manufacture of Blue-veined Cheese in the Midwest. C. B. Lane, Iowa Agric. Exper. Sta., Ames, Iowa. Nat. Butter and Cheese J. *29*, 12, p. 14, June 25, 1938.

Steps in the curd-making process are described. The ripening of the cheese by mold and the use of homogenization for the milk for making blue cheese are discussed briefly. The development of commercial manufacture of the blue cheese in the United States is reviewed and the prediction is made that the demand for this domestic product should increase materially during the next few years if high quality standards are maintained.

W.V.P.

383. Rate of Ripening in Cheddar Cheese. Theodore R. Freeman and C. D. Dahle, Pennsylvania Agric. Exper. Sta., State College, Pennsylvania. Technical Bulletin 362, May, 1938.

From an economic standpoint the ripening process is one of the most important phases of cheddar cheese production. This is especially true in obtaining the desired flavor in the cheese at the time it reaches the consumer. Also, by reducing the time required to ripen cheese, the cost may be reduced.

A study was made of seventeen lots of milk which were divided into moisture, acid, Rennin, Pepsin and Trypsin Series. Each lot from the different series was divided into two equal portions and the cheese made in separate vats. One cheese from each vat was ripened at approximately 45° F. and the other at approximately 63° F.

Analysis included bacterial content and type, pH, moisture content, amino nitrogen content and flavor score, except that the nine lots in the enzyme series were not subjected to the bacterial analysis.

It is concluded that:

The rate of proteolysis in cheddar cheese during ripening is directly related to the numbers of bacteria initially found in the cheese, as deter-

mined by the total count made on lactose and skimmilk agars and by the proteolytic count made on skimmilk agar.

There is no relationship between numbers of bacteria initially found in cheese and the development of flavor in the same cheese.

Changing the moisture content of the cheese through slight modifications in the curd-making process cannot be expected to influence materially the rate of ripening in the cheese.

The rate of proteolysis in cheddar cheese ripening can be increased 40 to 100 per cent by raising the ripening temperature from 45° to 63° F.

The maximum flavor score is reached more quickly when the cheese is ripened at 63° F. than when it is ripened at 45° F.

Cheese ripened at 63° F. will attain as high a maximum flavor score as that ripened at 45° F.

Low initial acidity in the cheese is conducive to more rapid proteolysis but has no significant effect on the rate of flavor development.

The quality of the aged cheese, as judged by flavor score, is slightly inferior in the low-acid cheese.

The occurrence of bitter flavor during aging is favored by a high ripening temperature.

Bitter flavor in cheese appears to be due to the presence of one or more of the substances resulting from the breaking down of casein.

Additional amounts of pure rennin increase the rate of proteolysis in cheddar cheese ripening, increase slightly the rate at which the flavor develops, and produce an aged product with slightly higher flavor score.

Added pepsin increases the rate of proteolysis during cheddar cheese ripening particularly at the beginning of the ripening period and at the lower ripening temperature, does not accelerate the development of flavor, but produces an aged product with appreciably higher flavor score.

Trypsin increases markedly the rate of proteolysis during the early part of the ripening period, after which its effect is greatly reduced. This enzyme also increases slightly the rate at which flavor develops, but reduced the maximum flavor score attained. W.D.S.

Other abstracts of interest are numbers 432 and 459.

CHEMISTRY

384. The Effect of Excess of Vitamins A, B and C on the Assay of Vitamin D and of Excess Vitamin D on the Assay of Vitamin A. HILDA M. BRICE and GEORGINA E. PHILLIPS, Pharmacological Laboratory of the College of the Pharmaceutical Society, London. Biochem. J. *32:* 1–4, 1938.

The response by the line test technique for vitamin D was not influenced by giving, at the same time, excessive doses of vitamins A, B or C (40 γ

carotene, 10–15 I.U. B, and 0.15 mg. ascorbic acid, respectively, daily per test animal. The weight response to a small dose of vitamin A was not influenced by giving a graded series of excessive doses of vitamin D (8–100 I.U. per animal per week). It is concluded by the authors that when assaying vitamin A or vitamin D, it is unnecessary to consider the possible presence of another vitamin in the substance under test, provided the basal diet is adequate. K.G.W.

385. Buffer Intensities of Milk and Milk Constituents. III. Buffer Action of Calcium Citrate. E. O. WHITTIER, Bureau of Dairy Industry, U. S. Dept. of Agric., Washington, D. C. J. Biol. Chem. *123:* 283, 1938.

"Equations describing the buffer action of calcium citrate have been derived and curves based on these equations compared with curves constructed from potentiometric titrations of calcium citrate solutions. Support is given the Hastings-McLeon idea of the mechanism of ionization of calcium citrate in solution."

"Application of the results of milk equilibria indicates that the buffer action of citrates in milk is exerted principally in the range in which phosphates and casein buffer most intensely and is of slight moment compared with the effects of these other buffer substances." K.G.W.

386. Note on the Quantity of Theobromine in the Milk of Cows Fed on a Diet Including this Alkaloid. H. C. DOWDEN, National Institute for Research in Dairying, Univ. of Reading. Biochem. J. *32:* 71, 1938.

In 1934 it was reported that cocoa shell is rich in vitamin D, and in 1935 that the feeding of 2 pounds of shell daily for a month during the winter raised the vitamin D content of the milk of stall-fed cattle to the normal summer level, while in 1937 it was found that the fat content of these milks was increased during the period of shell feeding.

Cocoa shell contains approximately 3 per cent of theobromine, and a cow receiving 2 pounds daily of the shell would receive approximately 9 grams of the alkaloid. Theobromine was fed in 9 gram quantities daily to a small group of cows for 3 weeks and on the last day samples of milk were analyzed for theobromine content. It was observed that in the milk of three cows the average daily milk yield of which was approximately 35, 19 and 18 pounds, the "theobromine" was respectively 4.71, 2.05 and 4.72 mg. per liter. In blank tests upon the method, yields of approximately 70 per cent of added theobromine were obtained. The maximum content of theobromine transmitted to the milk of the above three cows is, therefore, approximately 7 mg. per liter. According to a supplementary publication of the British Pharmacopoeia, the medicinal dose of theobromine is 0.3–0.6

gram. For a child under 12 months, for whom the dose would be $\frac{1}{12}$ of that prescribed for an adult, the minimum dose is contained in $6\frac{1}{4}$ pints of the milk. Plain eating chocolate contains approximately .3 per cent theobromine, and it is not uncommon for $\frac{1}{4}$ pound of this chocolate (containing 0.3 of theobromine) to be eaten by an adult at one time. K.G.W.

387. Analysis of Proteins. IX. The Content in Amino Acids of the Caseinogen and Lactalbumin of Woman's Milk. R. H. A. PLIMMER and J. LOWNDES, Chem. Dept., St. Thomas's Hospital Medical School, London, S.E. 1. Biochem. J. *31:* 1751, 1937.

The protein of cow's milk and woman's milk was concurrently analyzed for amino acid content. To compare the nutritive value of the protein of cow's milk with woman's milk, the cow's milk was generally diluted with an equal volume of water.

Except for cystine, which is the same in amount in cow's and woman's milks, cow's milk contains $\frac{2}{3}$ times the amounts of the other amino acids. Cow's milk diluted with an equal volume of water will contain half the amount of cystine present in woman's milk. If diluted with two volumes of water then tryptophane and possibly arginine will be below the amounts in woman's milk. Cow's milk diluted with an equal volume of water will have an equal amount of the sum of the sulphur bearing amino acids, cystine and methionine. K.G.W.

388. Dialysis of Milk. III. Salt Equilibrium with Special Reference to Calcium, Magnesium, and Phosphorus. L. H. LAMPITT, J. H. BUSHILL and D. F. FILMER, Lyons Laboratories, London, W. 14. Biochem. J. *31:* 1861, 1937.

It has been previously shown by these authors that the acidity of milk is of distinct importance in determining the dialysability of certain constituents, particularly salts. The results of this study show that acidification with either diluted or concentrated acids had the same effect on the amount of dialysable constituents.

Neutralization of acidified, raw, separated milk results in an almost complete recovery of the original amounts of dialysable Ca, Mg and inorganic P, although the figure for Ca remains slightly above normal.

The effect of extended agitation (14 days) on the dialysable constituents was studied. It is suggested that the salt equilibrium of milk is normally unstable and may be shifted by agitation. Treatment of the milk in its preparation for milk powder appears to stabilize the salt equilibrium.

The following ranges of analytical figures are presented for raw, pasteurized and dried, separated, "average" milk.

	Total	Dialysable (as % of total present)
Inorganic P	0.63–0.77	33–44
Organic P	0.31–0.38	7–15
Ca	1.27–1.44	25–42
Mg	0.10–0.15	62–83

K.G.W.

389. **The Milk Clotting Action of Papain.** A. K. BALLS and S. R. HOOVER, Bur. of Chem. and Soils, U. S. D. A., Washington, D. C. J. Biol. Chem. *121:* 737, 1937.

The milk clotting component of papain appears to possess activity in agreement with the conception for papain proteinase. The component is activated by H_2S, cysteine, phenylhydrazine, and cyanide, and has a high temperature optimum.

The time required for clotting was shown to be a straight line function of the enzyme concentration; a quantity of the enzyme, constant for any condition, is inactivated by the milk. K.G.W.

390. **The Position of the Unsaturated Linkage in the Hexadecenoic Acids of Certain Natural Fats.** JOHN M. SPADOLA and R. W. RIEMENSCHNEIDER, Bur. of Animal Ind., U. S. D. A., Washington, D. C. J. Biol. Chem. *121:* 787, 1937.

The hexadecenoic acid present in goat milk fat, egg yolk glycerides, and the depot fat of the white rat is chiefly the 9-, 10-hexadecenoic acid.

K.G.W.

DISEASE

391. **Sterility in Cattle Symptom not Disease.** C. R. DONHAM, Ohio Agric. Exper. Sta., Wooster, Ohio. Ohio Exper. Sta. Weekly Press Bull. XXIII–18, July 7, 1938.

Sterility in cattle is not a specific disease, but symptom of a large number of different diseases. Appropriate treatment can be applied only after intelligent diagnosis by a competent veterinarian. W.E.K.

392. **Results of Calfhood Vaccination.** L. J. TOMPKINS, Sheffield Farms Company, N. Y. Cert. Milk *13,* 141, p. 7, Jan., 1938.

This article summarizes the results up to date of a field experiment in calfhood vaccination for Bang's disease which was started in January 1934. The results of the research work done show that when calves are vaccinated between the ages of four and eight months with an appropriate vaccine, the agglutination titre disappears in a relatively short time, leaving the animal immunized to some degree. W.S.M.

Another abstract of interest is 401.

FOOD VALUE OF DAIRY PRODUCTS

393. Milk the Most Perfect Food. N. N. GODBOLE, Benares Hindu Univ., Dipawali, India, 1936. Distributed by Chemical Publishing Co., 148 Lafayette St., N. Y.; Price $1.25.

The title of this book is not sufficiently broad to include the full text, for the author really presents the dairy industry of India with special reference to improvement of the Hindu diet through increased consumption of dairy products. For American readers this style is particularly interesting for the literature on the food value of milk has not been materially increased by researches in India while knowledge of dietary conditions in India is not too general.

The promotion of the vegetarian diet is uppermost in the thoughts of the author which is essential in India for both religious and health reasons. India has neither supervision of the slaughter and handling of meats nor refrigeration in a country where summer temperatures are usually above the temperature of the human body. Fortunately, for the nutrition of the people, milk is accepted in the vegetarian diet for life need not be destroyed to secure it. Milk is served fresh in fluid form, or as ghee, butter, and fermented drinks. The total per capita yearly milk consumption is only about 85 pounds, caused principally by the very low production of the cattle. It is estimated that India has 52,500,000 milk cows and 20,500,000 she-buffaloes, the former producing 100 pounds and the latter 1200 pounds of milk per year in excess of that required by the calves.

The material in this book is presented in a very elementary manner for general public reading. Some printing errors are obvious, and exception may be taken to some of the ideas expressed by the author. Nevertheless, the book is both interesting and informative. A.C.D.

394. The Value of Milk Protein in Infant Feeding—Part II. P. B. CASSIDY and H. H. PERLMAN, Pediatric Society, Philadelphia, Pa. Cert. Milk *12*, 139, p. 5, Nov., 1937.

A discussion on the following questions:

1. Is the protein of cows' milk a cause of infantile eczema?

2. Does a high temperature have a favorable or unfavorable effect upon the protein in cows' milk?

3. What is the nutritional physiologic significance of milk protein?

4. What is the comparative economic status of milk protein as found in the various forms of milk: whole milk, evaporated milk, etc.?

W.S.M.

395. The Cow—"Mankind's Foster Mother." W. E. KRAUSS, Ohio Agric. Exper. Sta., Wooster, Ohio. Cert. Milk *12*, 140, p. 7, December, 1937.

This paper discusses the relationship between the feed of the cow and the composition of the milk, emphasizing the vitamin content.

W.S.M.

396. **Soft Curd and Homogenized Milks.** IRVIN J. WOLMAN, School of Medicine, Univ. of Pennsylvania, Philadelphia, Pennsylvania. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 114, 1937.

The pH of the stomach contents of a healthy infant seldom falls below 5.0. The iso-electric point of casein is 4.7 while the optimum pH for action of pepsin is 2.8. Acidity in the stomach of the infant is not favorable for action of pepsin, but in the young adult stomach a pH of between 3.0 and 1.4 is reached so active digestion by pepsin is obtained.

An artificial digestion device in which milk and milk formulae were subjected to the chemical action of synthetic gastric juice made from hydrochloric acid and pepsin is described. The production of fine soft curds by the addition of banana powder and banana pulp is described. Commercial methods of producing soft curd milk are briefly discussed. Clinical evidence shows that the milk preparations which yield soft curds are well tolerated and well utilized by infants, children and older persons, and that soft curds mean fine curds. Better control and standards are needed for these products.

E.F.G.

397. **Lime and Phosphorus, and Their Significance to the Milk Dealer.** WALTER H. EDDY, Columbia Univ., New York City. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 96, 1937.

The role of calcium and phosphorus in nutrition is discussed. Dr. Sherman in recommending a quart of milk per day for growing children bases this upon the fact that the child needs about 1 gram of calcium per day for body maintenance and growth and this is contained in the quart of milk. Milk is a better source of calcium than vegetables. Utilization of calcium and phosphorus is dependent upon vitamin D. A more acid condition in the digestive tract favors solubility of calcium. The parathyroid gland has a specific effect upon calcium assimilation. An outline is given of a procedure to check satisfactory calcium and phosphorus assimilation.

E.F.G.

398. **The Effect of Season and Feeds on the Vitamin D Content of Milk Under South Dakota Conditions.** G. C. WALLIS and T. M. OLSON, South Dakota Agric. Exper. Sta., Brookings, So. Dakota. So. Dakota Exper. Sta. Bull. No. 321, March, 1938.

Six grade Holsteins were used to study the effect of the season of the year and of the feeds consumed by dairy cows on the vitamin D content

of the milk produced. A marked seasonal effect was found. Summer milk contained 32 International Units of vitamin D per quart which was about four times the amount of vitamin D contained in the winter milk produced under the conditions of this experiment.

The vitamin D in the feed eaten by the cow also had an important influence on the amount in the milk produced. When the vitamin D intake was increased the milk became proportionately richer in this important food factor. The alfalfa hay used in this experiment contained 500 International Units of vitamin D, and the Prairie hay 250 International Units of vitamin D per pound. The hay was fed at the rate of 20 pounds per day so the cows getting alfalfa hay received 10,000 International Units of vitamin D daily, and the cows getting prairie hay received 5,000 units. This difference in intake was reflected in the higher vitamin D content of the milk produced by the cows receiving alfalfa hay. However, only a small proportion (between 1 and 2 per cent in this case) of the vitamin D in the feed consumed was recovered in the milk.

Because of the importance of milk as one of the few food sources of vitamin D, advantage should be taken of all factors which will contribute towards increasing the antirachitic value of milk. Some of these factors have been indicated in this bulletin while others will require further study. C.C.T.

399. **What If There Were No Milk?** NINA SIMMONDS, College of Dentistry, Univ. of California. Milk Plant Mo. *27*, 2, p. 32, Feb., 1938.

Milk is discussed chiefly from the standpoint of its calcium content, the role of which in dentition is emphasized. G.M.T.

400. **A Note on the Vitamin D Content of Cow's Colostrum.** KATHLEEN M. HENRY and S. K. KON, National Institute for Research in Dairying, Univ. of Reading. Biochem. J. *31:* 2199, 1937.

The vitamin D content of the colostral fats of a Guernsey cow on pasture was 1.2 I.U. per gram for the O and first day *post partum,* 0.56 I.U. per gram for the second, third, and first half of the fourth days, and 0.36 I.U. per gram for the last half of the fourth and first half of the fifth days. Normal control butterfat from a cow on the same ration contained 0.41 I.U. per gram. Compared with later milk, colostrum contains relatively more vitamin A and carotene than vitamin D. K.G.W.

401. **The Relation of Fat to the Utilization of Lactose in Milk.** E. J. SCHANTZ, C. A. ELVEHJEM and E. B. HART, Dept. of Agric., Univ. of Wisconsin, Madison, Wis. J. Biol. Chem. *122:* 381, 1938.

Rats placed on a mineralized whole milk diet made very efficient utilization of all the milk sugar. This has also been found to be true for a pig

and a calf. When the animals were placed on a mineralized *skim* milk diet, sugar was readily detected in the urine after a few days of feeding. The sugar was identified as galactose and accounted for all of the reducing material in the urine. In the case of the rat, as high as 35 per cent of the ingested galactose was recovered in the urine. Fats such as butterfat, lard, corn oil, cocoanut oil, linseed oil, and palmitic and oleic acids, when added to mineralized skim milk at levels of 3 to 4 per cent, prevented this loss in the urine. Glycerol or butyric, β-hydroxybutyric, caproic, and lactic acids did not prevent the loss. On mineralized skim milk the sugar of the blood rose to about 200 mg. per cent, while on whole milk it seldom rose higher than 140 mg. per cent after feeding. K.G.W.

Other abstracts of interest are numbers 384, 386, 387, 428, 444 and 454.

HERD MANAGEMENT

402. Some Calf Disorders of Nutritional Origin. C. E. Knoop, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–6, Apr. 14, 1938.

Many calf disorders may have nutritional origin, chiefly because of lack of certain minerals and vitamins. Lack of vitamin A and iodine are cited particularly. W.E.K.

403. Grain, Silage, Hay Supplement Pasture. A. E. Perkins, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Agr. Exp. Sta. Weekly Press Bull. XXIII–10, May 12, 1938.

It is pointed out that it is seldom economical to attempt to compensate for all the deficiencies of poor pasture by means of grain only. The use of silage, hay, or a cultivated pasture crop, such as Sudan grass, in connection with a low rate of grain feeding, is recommended.

W.E.K.

404. Pasture, Cause of Milk Slump. C. F. Monroe, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–16, June 23, 1938.

The marked decline in milk production often experienced after the first flush from pasture is probably due to an actual shortage of palatable grass. To prevent this drop the practice of rotating pastures is suggested.

W.E.K.

ICE CREAM

405. The Merchandising Council in 1937. G. V. Rector, Fairmont Creamery Co., Omaha, Neb. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *4:* 7, 1937.

During the past year the activities of the Ice Cream Merchandising Institute were increased. One important phase of the work was a series of 14 two-day regional merchandising conferences, so planned that they fairly covered the country geographically.

The monthly publication of the institute, "The Spinning Wheel," was continued for the benefit of sales and advertising managers of ice cream companies. Another monthly publication, "Ice Cream Currents," is planned primarily for the retail dealer. Ice cream manufacturers can purchase copies at 4 cents per copy for distribution to their dealers. Two talking slide films have been prepared for use by ice cream merchandisers; the one is intended for showing to retail dealers, the other is of interest to consumers.

The Ice Cream Merchandising Institute also offers personal information service to manufacturers with specific ice cream merchandising problems.

M.J.M.

406. What Have You to Sell? GEORGE W. HENNERICH, Ice Cream Merchandising Institute, Inc., Washington, D. C. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *10:* 4, 10, 1937.

The importance of a constructive selling program is stressed by the author. Merchandising of ice cream at the soda fountain is then discussed from the standpoint of profitable operation. The home delivery of ice cream was also found to be a profitable way of selling the product.

M.J.M.

407. Showmanship in the Ice Cream Industry. ZENN KAUFMAN, New York, N. Y. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *10:* 4, 20, 1937.

The author discusses the elements which he feels are essential in successful salesmanship and gives numerous illustrations of how these elements have been successfully employed. M.J.M.

408. Specialties—Their Place in Industry. NORMAN THOMAS, Joe Lowe Corp., New York, N. Y. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *10:* 4, 35, 1937.

Although bulk ice cream is the mainstay of the ice cream industry, it is true that a greater number of flavors and specialties will increase the gallons of ice cream sold in any store. Specialties which are properly packaged, stored and handled will add to the profits of an account. The ice cream salesman is urged to determine the relative amount of profit for bulk ice cream and specialties and properly instruct the retail dealer along these lines.

The ice cream maker is urged to handle only such specialties or novelties

which offer the basis of size and price control. Oversized and underpriced novelties have been the source of a considerable amount of trouble. Legal size and price control have protected numerous markets from difficulty with specialties. M.J.M.

409. Retail Store Trends. O'NEAL M. JOHNSON, Statistical and Accounting Bureau, I. A. I. C. M., Washington, D. C. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *10:* 4, 44, 1937.

The author has found that 23.9 per cent of the manufacturers sell ice cream through retail stores, but the ice cream sold in this manner represents only 11.5 per cent of the total sales. Only 15 per cent of the ice cream manufacturers operate more than one retail store.

The types of stores operated, the kind of merchandise featured, the average selling prices, and the kinds of cones sold are tabulated for the ice cream stores studied. A considerable amount of data are presented and many problems arising in retail selling are discussed. A manufacturer who is considering the sale of ice cream through retail stores should find this information very helpful. M.J.M.

410. Retail Stores. A Discussion. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfrs. *10:* 4, 68, 1937.

(1) LLOYD D. WITTER, Snowhite Creameries, Inc., San Angelo, Texas.

With the advent of new developments, the ice cream industry has been changed from time to time. The retail store is a present day trend which may mean another transition point in the industry. The retail store came into existence in the depression years as a result of intense competition and decreased gallonage of sales through the regular outlets. The place of the retail store in the industry is questioned by some and upheld by others.

Retail stores will continue to be successful so long as the public is offered: Products of quality; A variety of flavors; Attractive surroundings; Convenience and service; And, most important, values.

(2) D. H. DORMAN, Protected Milk Products, Kansas City, Missouri.

Our company has operated a few retail stores over a period of four years. Until the past year the stores were not equipped for Fountain service. The addition of the fountain stores proved very successful. The retail store also proved to be very helpful in promoting specialties.

(3) E. B. DARROW, Darrow Ice Cream Co., Albuquerque, New Mexico.

Our experience with a retail store has been over only a five months' period. Nothing but package goods is sold—brick ice cream and five-cent items in package. No attempt was made to call attention to the retail store, by advertising. Yet through the store as much brick ice cream has been sold as by the ten best dealers handling our ice cream. We have found that packaged ice cream can be sold successfully through the retail store.

(4) CARL A. STEEL, Steel De Soto Ice Cream Co., Minneapolis, Minn.

A retail store was opened by our company in a town where the company operated two ice cream routes. After a few months it was found that more ice cream was being sold through the store than through the two routes.

It is believed that operating both a retail and wholesale ice cream business on a large scale is not practical. However, by operating a few retail stores it might be possible to show the dealer how to merchandise ice cream successfully by operating his store as an ice cream store during the short busy season.

(5) G. D. TURNBOW, Protected Milk Products Co., Oakland, California.

The retail store spread is only one of several fundamentals in successful operation of this type of business. Such elements as the traffic count, location of store, construction of store, products to be sold, and many other details, must be decided on before retail store spread becomes a factor.

We have found it difficult to find properly trained personnel and managers for the ice cream stores. Volume is also essential. A successful store must handle in excess of 5,000 gallons a year.

With ice milk, a gross spread of 47 per cent should be realized. Our aim for an average spread on all products is 42.5 per cent.

The proper training of new employees is paramount. They are first trained in a manner similar to that used in the classroom. Following this they work for a period of time under a trained supervisor.

The store manager is given a bonus for obtaining sales quotas on certain products and on the entire quota for the set up for the month. In addition, a special bonus is given to the managers who maintain the required store spread for the month. M.J.M.

411. **Sodium Alginate—A Stabilizer.** V. C. STEBNITZ and H. H. SOMMER, Dept. of Dairy Industry, Univ. of Wis., Madison, Wis. Ice Cream Field *32*, 3, p. 48, March, 1938; 4, p. 52, April, 1938.

The authors compared the stabilizing properties of sodium alginate (Dariloid) with those of gelatin of the following Bloom strengths 150, 175, 200, 225 and 250. The mixes were prepared in accordance with commercial practice except that they were processed in much smaller batches. The ice cream was frozen using a 2½ gallon vertical brine freezer.

The authors report that the addition of 0.2 per cent "Dariloid" caused an increase of 0.08 to 0.10 in the pH of the mix whereas 0.3 per cent "Dariloid" resulted in an increase of 0.13 to 0.17 pH. These additions caused a decrease in titratable acidity of 0.10 and 0.015 per cent respectively.

In contrast with the above, the various gelatins caused no appreciable change in either the pH or titratable acidity when added to the mix.

Mixes containing gelatin were found to have the same color as the control mix without any stabilizer, while the sodium alginate mixes showed slightly more color.

Measurements of viscosity showed the sodium alginate mixes to be more viscous than gelatin mixes when freshly prepared, whereas after aging this difference did not necessarily persist. They report that agitation of the sodium alginate mix caused a considerable decrease in viscosity which was not regained by subsequent aging.

No tendency to whey off occurred with the sodium alginate or gelatin mixes.

When sodium alginate mix was cooled to 60° F., aging seemed to improve its whipping ability whereas if cooled to 40° F. immediately after homogenization, aging did not improve the whipping property. The authors state "The difference in whipping ability between gelatin and sodium alginate seems to depend to a large extent upon the condition of the freezer and the amount and strength of the gelatin used—Excessive amounts of sodium alginate seemed to have the same deterrent effect on the whipping ability as excessive amounts of gelatin."

According to the authors there was practically no difference in body and texture of ice creams made with sodium alginate and gelatin when the correct amount of each was used.

The authors claim "As a stabilizer for ice cream, sodium alginate shows all the desirable properties of the other ice cream stabilizers and in addition shows some distinct advantages." In this connection they emphasize particularly the advantage of uniform viscosity during the aging of sodium alginate mixes. W.C.C.

412. **Viennese Ice Cream Stresses Flavor.** ANONYMOUS. Ice Cream Field *32*, 3, p. 54, March, 1938.

Viennese ice cream, according to Sidney Freier, an ice cream manufacturer of Vienna, is made with egg yolks (10 to 20 yolks for 1 quart of ice cream), milk, cream, butter and 18 per cent sugar. He claims the flavor must be very pronounced, *e.g.*, 30 to 40 per cent crushed fruit is used in Viennese fruit ice cream; the taste is never doubtful.

Coffee is the most popular flavor in Vienna followed by nougat or hazelnut. Strawberry is also a popular flavor, but vanilla and chocolate are in little demand.

Mr. Freier feels that more emphasis should be placed upon flavor in this country, but he is impressed with the magnitude speed and efficiency of American machines. W.C.C.

413. **The Small City Plant.** M. W. YALE and R. C. HICKEY, N. Y. Agr. Exp. Sta., Geneva, N. Y. Ice Cream Field *32*, 3, p. 34, March, 1938.

"In general, venders of ice cream take poor sanitary care of dippers and scoops" according to the authors. They claim further that small

retailer manufacturers are, as a group, least familiar with sanitary principles.

They state further, "the greatest need for improvement in sanitation appears to be in the dispensing of bulk ice cream in a cleaner and more sanitary manner. However, this need is no greater than that for improvement in the handling of many other foods and beverages; and it is doubtful whether ice cream should be singled out for action. The whole question of sanitation in respect to food handling is receiving and should receive much attention at the present time." W.C.C.

414. The Use of Lecithin. J. H. Erb and H. Collins, Ohio State Univ., Columbus. Ice Cream Field *32*, 5, p. 42, May, 1938.

Dipping chocolate bars ordinarily results in the incorporation of some moisture in the coating which increases its viscosity and decreases the amount of surface coverage. The addition of 0.2 to 0.4 per cent lecithin tends to reduce the increase in viscosity due to water dilution. W.C.C.

415. Egg Yolk as a Mix Ingredient. C. D. Dahle, Penn. State College, State College, Pa. Ice Cream Field *32*, 5, p. 25, May, 1938.

The author points out that since 1920 the commercial use of egg products for ice cream manufacture has increased materially. Egg yolk improves the whipping properties of ice cream mixes especially those made with butter or frozen cream as the sources of fat. Often beneficial results are also obtained from its use in chocolate ice cream.

The various types of egg products available for use in ice cream are considered and a brief discussion presented as to the possible constituents of egg yolk which may be responsible for the improved whipping qualities of the mix. W.C.C.

416. Use of Anti-Oxidants in Ice Cream. A. C. Mack and P. H. Tracy, Dept. Dairy Industry, Univ. of Ill., Urbana, Ill. Ice Cream Rev. *21*, 6, p. 82, Jan., 1938.

Oat flour was added to ice cream mixes containing three p.p.m. of added copper. The amount of oat flour added ranged from 0.1 to 0.5 per cent. In order to be assured of ample anti-oxidative protection in vanilla ice cream it is recommended that 0.5 per cent oat flour be added. Various methods of adding oat flour to the mix were studied. The most satisfactory methods were to add the oat flour to the mix with the sugar or to add it in dry form at the freezer. It was found more difficult to control the development of stale metallic flavor in strawberry ice cream by the addition of oat flour than in vanilla ice cream. Oat flour added at the rate of 0.5 per cent delayed the oxidized flavor development. J.H.E.

417. Profitably Priced Packages Preferred. J. H. Carothers, Los Angeles, California. Ice Cream Rev. *21*, 9, p. 44, April, 1938.

In order to give the consumer a better quality and more fairly priced package the overrun should be controlled, and a price should be set on the package which would allow a fair margin of profit, to the manufacturer and the dealer. It is suggested that the price be set on a unit basis so the dealer will know a certain profit will be made on each individual unit sale.

J.H.E.

418. A Study of the Qualities of Commercial Ice Cream. W. H. Brown, Dairy Dept., Purdue Univ., Lafayette, Indiana. Ice Cream Rev. *21*, 9, p. 110, April, 1938.

Analytical and bacteriological results compiled on 570 samples of commercial ice cream at Purdue University are tabulated and discussed.

J.H.E.

419. Controlling Stale Flavors in Ice Cream. K. G. Weckel, Dept. of Dairy Industry, Univ. of Wis., Madison, Wis. Ice Cream Rev. *21*, 9, p. 35, April, 1938.

State flavors in ice cream originate through the use of inferior ingredients, inadvertent equipment effects, and slow turnover of the product. Contributing factors to each of the above are discussed and precautions and remedies suggested. J.H.E.

420. Ice Cream Regulations. M. G. Young, Missouri Dept. of Health. Ice Cream Rev. *21*, 6, p. 28, Jan., 1938.

The consumer of ice cream and other dairy products is entitled to the same health protection as the consumer of a bottle of fluid milk. Factors discussed are the regulation of the raw products going into ice cream, the control problems arising since the development of counter freezers, the question of requiring pasteurizing of mix and manufacture of ice cream to be a continuous process, and the sanitary conditions of the retail outlet.

J.H.E.

421. Refrigeration in the Ice Cream Industry. W. L. Pharo, York Ice Machinery Corp., Charlotte, N. C. Ice Cream Rev. *21*, 9, p. 46, April, 1938.

The most common cause of inefficient refrigeration plant performance can be credited to high condensing pressures. An illustration is given showing the increased cost of operation due to excessive head pressure. The most common causes of high pressures are non-condensable gases in the system, dirty condensers, lack of condensing water or condensing water not cool enough, and lack of sufficient condensing surface. J.H.E.

422. Frosted Malted. Anonymous. Ice Cream Field *32*, 1, p. 7, Jan., 1938.

Frosted malted milk is not ice cream, instead it is a sherbet with low butter-fat content. It has been characterized as the "drink you eat with a spoon," actually it is a semi-frozen product that is eaten with a spoon.

Special mixers are used for making this product which are illustrated.

Under the caption "How it's done" is given a formula for the manufacturer and one for the retailer. W.C.C.

Editor's Note. "This product is what is generally known as 'Ice Milk.'"

423. Frosted Malteds. Anonymous. Ice Cream Rev. *21*, 10, p. 32, May, 1938.

A large wholesale ice cream manufacturer introduced a Frosted Malted ice milk and secured highly satisfactory results by adding milk to the product and mixing it on a fountain mixer. It is a product low in fat content and high in total solids making it an ideal hot weather drink. A formula is given for its manufacture. J.H.E.

424. Large Scale Production of Fancy Ice Cream, Chocolate-Coated Bars and Specialties. Charles Weinreich, Cherry-Burrell Corp., Chicago, Ill. Ice Cream Rev. *21*, 10, p. 88, May, 1938.

Consumption of ice cream novelties has increased until today about 25 per cent of all ice cream manufactured is in this form. Several methods are outlined for the production of chocolate-coated ice cream bars.

J.H.E.

425. Routine Calculation of Ice Cream Mixes. Carl Duncan. Ice Cream Rev. *21*, 8, p. 41, March, 1938.

Instruction, using sample mixes for demonstration, is given for standardizing the ice cream mix. J.H.E.

426. The "Big Ten" in Ice Cream Merchandising. R. F. Gilbert, Hydrox Corp., Chicago, Ill. Ice Cream Rev. *21*, 9, p. 96, April, 1938.

Ten specific points are suggested for successful ice cream merchandising at the soda fountain. J.H.E.

427. Making Ice Milk Mix from Ice Cream Mix. H. A. Collins, San Jose, California. Ice Cream Rev. *21*, 10, p. 38, May, 1938.

Calculations are explained for standardizing ice milk from regular ice cream mix. J.H.E.

428. Ice Milk. G. D. TURNBOW, Oakland, California. Ice Cream Rev. *21,* 10, p. 30, May, 1938.

The author justifies the existence of ice milk, a product similar to ice cream, but containing only 4 per cent milk fat. He states it merits development and regulation because it is a tasteful confection, it has exceptional food value, and is important in the economic structure of the dairy industry. The author states that in 1936 California produced 15,664,734 gallons of ice cream and 7,190,587 gallons of ice milk. J.H.E.

429. Diabetic Ice Cream. B. E. HORRELL, Dairy Dept., Purdue Univ., Lafayette Indiana. Ice Cream Rev. *21,* 10, p. 46, May, 1938.

Two formulas for ice cream suitable for people afflicted with diabetes are given. Saccharin is the sweetener in place of sugar. J.H.E.

430. Seasonal Specialties. JOHN CLAITOR. Ice Cream Field *32,* 3, p. 42, March, 1938.

Several recipes are given for small ice cream manufacturers who are not equipped to homogenize their mixes. W.C.C.

431. Bacteria in the Mix. D. LEVOWITZ, New Jersey Laboratories. Ice Cream Field *32,* 9, p. 10, March, 1938; *32,* 4, p. 23, April, 1938; *32,* 5, p. 15, May, 1938.

The author attempts to describe some of the elementary principles of microbiology in very simple terminology. Different types of organisms are illustrated, some of the sources of contamination discussed and desirable practices indicated. W.C.C.

Other abstracts of interest are numbers 372, 373, 375, 447, 449, 450, 452, 455, 459, 463 and 464.

MILK

432. Seasonal Changes in Market Milk Production in Pennsylvania. The Relation of Month-to-month Fluctuations in Milk Sales to Prices Received by Farmers. F. F. LININGER and C. W. PIERCE, Pennsylvania Agric. Exper. Sta., State College, Pa. Bull. 358, April, 1938.

There is a wide variation in the amount of milk produced during the different seasons of the year. In many cases there is twice as much shipped in June as there is during the month of November. Records of milk shipments indicate a trend toward more variable production in the Philadelphia and Pittsburgh milk sheds following the abandonment of the base-surplus plans a few years ago. Seasonal sales of milk from farms have always

varied widely in the New York milk sheds, where no plan for the specific purpose of leveling production has ever been in general use.

The report deals with the seasonal production, distribution of sales and prices for the three large markets, New York, Pittsburgh, and Philadelphia, drawing supplies from the state of Pennsylvania.

The average per cent of milk received by these three markets during the month of November was 78.3 per cent while in June it was 131 per cent, using 100 per cent as the average for the year. In the Philadelphia market during the month of November 87.6 per cent of the milk received was used for fluid milk purposes, while in June only 58 per cent of the milk received was used for fluid milk purposes.

Because fluid milk distributors must have an adequate supply of milk during the low periods of production, they have a supply in excess of their fluid requirements during the remainder of the year as a result of fluctuating production.

The average price paid producers depends largely on the percentage of the total supply sold for fluid uses. Therefore, prices are higher in the fall and winter months than during the spring and early summer months. Production is more varied in both the Pennsylvania section of the New York milk shed and in the Pittsburgh milk shed than in the Philadelphia milk shed. Seasonal fluctuation in production in the Pittsburgh and Philadelphia sheds have increased since the discontinuance of the "basic-surplus" plans during 1933 and 1934. For all groups of producers seasonal fluctuations in production have widened since 1933.

A trend toward uneven milk production tends to widen a milk shed; to increase the cost of marketing by requiring additional investments in plants, equipment and trucking facilities necessary to handle peak summer milk supplies; and to increase seasonal fluctuations in average prices paid to producers for milk.

The present price system in Pennsylvania favors uneven production. For this reason many producers have been demanding a change in price policies which would favor even production. W.D.S.

433. The Use of Citric Acid and Sodium Citrate in Milk and Milk Products. Hugh L. Templeton, Univ. of Wisconsin, Madison, Wis. Wis. Agric. Exper. Sta. Res. Bull. 133, Nov., 1937.

Judges preferred those starters containing either citric acid or sodium citrate. The addition of citric acid or sodium citrate to the starter culture or to the cream to be used for butter-making, or both, seems to give a butter with a more pronounced flavor and aroma. The addition of two to six ounces of sodium citrate per thousand pounds of cream is effective for preventing feathering of cream because it counteracts the effect of calcium salts in either the water or the cream. The use of limited amounts of sodium citrate in

cream tends to minimize the cream plug defect and although large amounts completely eliminate cream plug, the flavor of the cream is affected adversely. Experiments with whipping cream show the addition of sodium citrate decreases the whipping time when the fat content of the cream is less than 35%. Other factors influencing the whipping of cream, such as fat content, temperature of pasteurization and the like were studied experimentally. Brief comments indicate the possible application of sodium citrate for stabilizing condensed milk, for aiding the ripening of natural cheese and for the production of soft-curd milk. Citric acid may be used advantageously in milk for infant feeding under a doctor's direction. W.V.P.

434. **Base and Surplus Plans Level Out Milk Production.** R. W. SHERMAN, Ohio Agric. Exper. Sta., Wooster, Ohio. Ohio Exper. Sta. Weekly Press Bull. No. XXIII–19, July 14, 1938.

Base and surplus plans in four Ohio markets have been an influence in leveling out the yearly supply of milk. In some instances the difference between the flush and shortage months was 10 pounds less per day than before the plan was in operation. W.E.K.

435. **Evaluation of Methods of Determining the Efficiency of Pasteurizing Milk.** E. H. PARFITT, Univ. of Purdue, Lafayette, Indiana. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 183, 1937.

The value of comparison of laboratory and commercial pasteurization, line testing, line bottle testing and coliform content is discussed and some figures given showing how each criterion is used. The author states the coliform content is one of the best. E.F.G.

436. **The Causes of Off-flavors in Milk; the Facts and a Theory.** J. A. ANDERSON, S. T. WILSON, and J. G. HARDENBERGH, Rutgers Univ., New Brunswick, New Jersey. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 177, 1937.

The authors' theory is that the oxidized, rancid, flat and insipid flavors which develop in milk of low bacterial content have their origin in a carotene deficiency in the ration. This effects the milk directly by reducing its carotene content and what appears to be more important causes a vitamin A deficiency in the cow which results in an abnormal distribution of enzymes in blood and milk. This accounts for excessive amounts of lipase found in milk which develops a rancid flavor. E.F.G.

437. **Plant Processing and Control Methods in Preventing Oxidized Flavor.** W. H. MARTIN, Kansas State College, Manhattan, Kansas. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 169, 1937.

Several treatments which have at times been suggested for preventing the flavor are mentioned. Factors on the production side which cause milk to be susceptible are listed. In the plant metallic contamination, cleaning and sterilizing and the effect of light at all points in processing and delivery is stressed. Discarding the first milk through the equipment is recommended.

E.F.G.

438. **Variations in Susceptibility of Milk as Secreted by the Cow.** E. O. ANDERSON, Connecticut State College, Storrs, Connecticut. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 153, 1937.

It is known that winter milk is higher in acidity and also more readily develops oxidized flavor than summer milk. Results on seven trials of .19% acidity milk compared with 7 trials of this milk reduced in acidity to .15% with $Na_2CO_35H_2O$ gave strong oxidized flavor in 4 of the former and only 2 of the latter samples at the end of 72 hours. Milk from different sources seems to vary in the reduction of acidity needed to inhibit oxidized flavor. The theory is advanced that the change in pH upon reduction in acidity has an effect upon enzymes secreted by the cow; that the cause and prevention of oxidized flavor is intimately associated with the nutrition of the animal.

E.F.G.

439. **Off Flavors in Raw and Pasteurized Milk.** G. M. TROUT, Michigan State College, East Lansing, Michigan. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 131, 1937.

The flavors of 920 cans of raw milk on a hot August day are reported as follows:

Flavor	No. of cans	% distribution
Clean and pleasant	413	44.89
Feed	219	23.80
Musty	101	10.97
High acid	73	7.93
Unclean	58	6.30
Barny	13	1.41
Cowy	12	1.30
Oily	13	1.41
Miscellaneous	18	1.95
Total	920	99.96

Flavors in the pasteurized milk of 22 dealers during September and October are given as follows:

Flavor	Percentage distribution Fresh 1 day	After 3 days
Clean, pleasant	13.3	12.0
Cooked or heated	65.5	30.9
Oxidized	5.5	20.7
Barny	4.4	......
Cowy	3.3	......
Metallic	1.1	5.2
Unclean	1.1	9.6
High acid	1.1	......
Stale	......	10.3
Flat	......	10.3
Sour	......	1.7
Total	99.7	99.7

Some flavors in raw bottled milk, homogenized and irradiated milk are mentioned. E.F.G.

439a. **Theoretical Aspects of the Cause of Oxidized Flavor Particularly from the Lecithin Angle.** L. M. THURSTON, Univ. of Florida, Gainesville, Florida. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 143, 1937.

The author suggests the following classification of milks from the standpoint of oxidized flavor:

1. Spontaneous milk: Milk which is capable of developing oxidized flavor spontaneously, *i.e.*, without the presence of iron or copper as a contaminant.

2. Susceptible milk: Milk which does not develop oxidized flavor spontaneously, but is susceptible in that contamination with copper or iron will cause development of the flavor.

3. Non-susceptible milk: Milk in which oxidized flavor cannot be produced by the addition of copper or iron.

The theory of an oxidizing enzyme in "spontaneous milk" of the catalytic effect of Fe and Cu in susceptible milk and the presence of increasing proportions of reducing substances in non-susceptible milk is discussed. Vitamin C is important in the latter instance.

Attention is called to the results obtained by various investigators to indicate the possibility of lecithin being the material oxidized in the case of "susceptible" milk, whereas in spontaneous milk it is both butterfat and lecithin-cephalin. The most likely present theory to explain the non-appearance of oxidized flavor in homogenized milk is the increased adsorption of protective protein on the surface of the fat globule.

Some reduction of the development of the flavor in milk agitated or frozen may possibly be explained by a reduced fat surface. "Spontaneous" milk heated to 165 to 168° F. probably results in destruction of the enzyme. Sun-

light alone is an oxidizing agent and the flavor produced differs from the so-called oxidized flavor found in "spontaneous milk" or caused by copper in susceptible milk.

E.F.G.

440. The Resazurin Test for Sanitary Condition of Milk. G. A. RAMSDELL, Bureau of Dairy Industry, U. S. D. A., Washington, D. C. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 3, 1937.

The resazurin test is found to be more rapid than the methylene blue test, and to be more sensitive to the reducing influences of pathological milks and physiologically abnormal milks. With the short incubation period of one hour the flora approximates more closely the initial flora than when longer incubation periods are used. The rate of change of color from blue to pink over several hours of incubation gives considerable information relative to the types of flora existing in the milk.

E.F.G.

441. The Practical Value of the Phosphatase Test in Determining the Efficiency of Pasteurization. F. W. GILCREAS and W. S. DAVIS, New York State Dept. of Health, Albany, N. Y. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 34, 1937.

The details of the procedure and reagents used for the phosphatase test are described. Variation in incubation time from 24 hours to 18 hours had no significant effect upon the accuracy of the results. Reagents prepared commercially and buffer substrate tablets were found satisfactory. The phenol concentrations corresponding to various degrees of treatment have been established. Variations of 5 minutes or greater in heating time were readily distinguished and the addition of .1% or more of raw milk gave results indicating incomplete pasteurization. Variations in temperature were also easily detected. High temperature process pasteurization could also be checked. Application of the technique to 780 samples collected from delivery trucks and labeled pasteurized, detected the treatment of the milk correctly in 96% of the samples.

E.F.G.

442. Determining the Efficiency of Milk Pasteurization. P. H. TRACY and A. J. HAHN, University of Illinois, Urbana, Illinois. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, p. 57, 1937.

After a fairly comprehensive review of the literature with reference to the phosphatase test including an explanation of the principles involved the author suggests several aspects of the test which require further study. The Scharer modification of the phosphatase test devised by Kay and Graham is described in detail and was used in the work reported in securing the following results. The authors report attempts to improve Scharer's method by the application of the photoelectric cell in determining the degree of the

phenol color formed, thus making it possible to make more accurate determinations of the amount of phenol present. The principle and construction of the photoelectric cell is given in detail. The photoelectric cell made possible the detection of as low as .1% raw milk. Differences in holding time were more difficult to detect at 145° F. than at 142° F. In either case a raw sample which could be pasteurized under controlled conditions is needed as a reference sample. Corrosive sublimate tablets were found to be usable for preserving milk to be examined by the phosphatase test. E.F.G.

443. **Dairymen Must Keep Milk Cold.** L. H. Burgwald, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–4, March 31, 1938.

Examinations of the milk sent into Columbus by 10 dairymen showed that during February and March there was a progressive increase in the temperature of the milk and in the bacterial count. This experience points to the necessity for careful cooling at all seasons of the year. W.E.K.

444. **Milk Trucking Interests Grow.** C. G. McBride, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–5, Apr. 7, 1938.

Because the trucking operation represents approximately 10 per cent of all the costs of marketing fluid milk, more economic control of this process is indicated. W.E.K.

445. **Make Survey of Family Milk Use.** Hughina McKay, Ohio Agr. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–8, Apr. 28, 1938.

A survey of 28,966 families in 59 cities revealed that the average weekly consumption of milk was 2.44 quarts; that less than 1 quart per person weekly was purchased by 4,126 families; that 529 of these families bought no milk W.E.K.

446. **A Study of Causes of Damage to Cap, Seat and Bead of Comalac Universal Milk Bottles.** Marcus Dey, Golden State Co., Ltd., Los Angeles, California. Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 21, 1937.

This comprehensive study was undertaken at the direction of Comalac, reported to be the largest purchaser of milk bottles in this country, to discover the causes of so much chippage on the tip and bead of Comalac bottles. Some of the results are:

1. 2.9 per cent of new quarts received from the factory were defective.
2. Differences in chipping were observed in ware from different plants. "Over pressed" cap seats were a contributing factor.

3. Two wire cases are a definite cause of bead chippage and their use should be discontinued.

4. Bottle washing operations cause extreme damage to bead and cap seat. Comparisons of washers are given and suggestions for operation to reduce injury to bottles.

5. Corrosive bottle washing materials cause spalled glass and is the forerunner of etching and chipping. The solubility of glass in various washing materials is given. The least solubility, .878 per cent, was obtained with a mixture of flake caustic 50 per cent and sodium metasilicate 50 per cent.

6. Capping machines do not damage the cap seat.

7. Significant damage to the bead or finish resulted when filled bottles were cased 4 at a time but not when cased 2 at a time.

8. Only 1.6 per cent of bottles were damaged on the bead when in the hands of retail customers.

9. Investigation of handling and transporting of cased bottles deserves to reduce damage. Specific recommendations are given. E.F.G.

447. How Milk is Produced and Distributed in the Argentine. W. Bob S. Fels, Sales Mgr. of the farm-ranch, "Estancia Tatay," Buenos Aires, Argentine. Milk Dealer *27*, 5, p. 40, Feb. 1938.

A description of the milk industry in the Argentine, especially as carried on by the farm-ranch Estancia Tatay. This farm-ranch has approximately 15,000 head of cattle and the milk is pasteurized on the farm where it is produced.

C.J.B.

448. Preventing the Oxidized Flavor in Milk and Milk Products. C. D. Dahle, Dairy Dept., Penn. State College, State College, Pa. Milk Dealer *27*, 5, p. 68, Feb. 1938.

A report of experimental work with oxidized flavor in milk. The author draws the following conclusions: 1. There are numerous means for delaying or preventing the onset of flavors in dairy products that are of an oxidative nature. 2. In milk, in which the flavor develops spontaneously, high temperature (170° F.), homogenization, nitrogen replacement of the free oxygen, increasing bacterial population, feed and anti-oxidants are effective. 3. Certain anti-oxidants in other fats are pro-oxidants in milk fat. 4. An anti-oxidant contained in oat flour proved to be particularly efficient.

C.J.B.

449. The Phosphatase Test for Determining Efficiency of Pasteurization. E. H. Parfitt. Milk Plant Mo. *27*, 1, p. 34, Jan. 1938.

The author gives a comprehensive summary of the phosphatase test, the principles involved, the methods used, applications and precautions.

G.M.T.

450. The Use of Chlorine Disinfectant in the Sterilization of Dairy Equipment. Lewis Shere. Milk Plant Mo. *27*, 1, p. 42, Jan. 1938.

Methods of sterilizing dairy equipment are given with special reference to the selection and use of chlorine, pointing out the differences in the corrosive action of chlorine sterilizers. G.M.T.

451. Now is the Time and Here is the Way to Tackle the Fly and Insect Problem. E. M. SEARLS, FRED M. SNYDER, and C. L. FLUKE. Milk Plant Mo. *27*, 4, p. 32, April 1938.

Precautions to observe in the selection and use of sprays are given as well as types of sprayers to use and methods for testing them. Life cycles of some insects are presented. A number of control measures are discussed. G.M.T.

452. Daylight Versus Night Delivery. F. E. ROGERS. Milk Plant Mo. *27*, 3, p. 28, March 1938.

A discussion of the possible changes in systems of milk delivery giving the advantages and disadvantages of the daylight delivery system. G.M.T.

453. What Makes Milk Stone, How to Prevent It and How to Eliminate It. H. A. RUEHE. Milk Plant Mo. *27*, 4, p. 30, April 1938.

The composition of milk stone is dependent somewhat upon the product, ice cream mix, cream, skim milk, or whole milk, from which it is precipitated. Generally formed by the precipitation of calcium, sodium, and magnesium phosphate by heat, it contains also some entrapped fat. Analysis of milk stone from a vat coil used for pasteurizing ice cream mix at 160° F. showed the milk stone to contain 43.54 per cent protein, 42.03 per cent ash and 12.44 per cent ether extract (fat); whereas holder pasteurized whole milk stone contained 31.19 per cent protein, 5.62 per cent ash and 42.65 per cent ether extract; and 180° F. skim milk stone had 37.82 per cent protein, 52.6 per cent ash and 6.08 per cent ether extract. Prevention of milk stone formation may be accomplished (1) by proper adjustment of the heating medium during pasteurization (2) by use of non-film-forming washing compounds with hard water and (3) by rinsing with cold water rather than hot when the water is hard. Equipment may be freed from milk stone deposits by use of $\frac{1}{10}$ of 1 per cent tartaric acid or by use of commercial compounds especially prepared for that purpose. G.M.T.

454. The Action of Sunlight on Milk. LASCAR BURUIANA, Dept. of Vet. Med., Univ. of Bucharest. Biochem. J. *31:* 1452, 1937.

The influence of various factors responsible for the reduction of methylene blue in milk exposed to sunlight has been reviewed experimentally, and certain phenomena distinguished.

Two effects are noted:

(1) Oxidation of unsaturated fat. This phenomenon is independent of the decoloration of methylene blue. The reduction of methylene blue is, however, aided by this oxidation of the unsaturated fat, which produces anaerobic conditions in the milk by using up the dissolved oxygen and thus allows the second phenomenon to appear.

(2) Oxidation by catalytic dehydrogenation of the ascorbic acid present in the milk. This dehydrogenation is responsible for the decoloration of the methylene blue, which serves as hydrogen acceptor. When all the ascorbic acid has been oxidized, the color of the methylene blue is restored if air or oxygen be admitted. The determination of the substances oxidizable by iodine before and after exposure to sunlight can be used to evaluate the vitamin C content of milk. The results of this method agree well with those obtained by direct titration with 2:6-dichlorphenolindophenol by the Schlemmer method. The rate of reduction of methylene blue on exposure of milk to sunlight does not give quantitative information of the content of ascorbic acid because this rate depends on the amount of unsaturated fat present, which plays a part described above as oxygen absorption. With the exception of mare's milk, the milks examined did not contain reduced glutathione. K.G.W.

455. Irradiation of Milk. Factors Affecting Antirachitic Response. H. H. BECK, H. C. JACKSON and K. G. WECKEL, Univ. of Wisconsin, Madison, Wis. Ind. & Eng. Chem. *30:* 632–639, 1938.

A study was made of factors affecting the efficiency of commercial irradiating equipment in the photochemical synthesis of vitamin D in fluid and evaporated milk exposed in flowing films. A high-pressure, air-cooled quartz mercury-vapor arc provided the radiation, the intensity of which was measured, recorded and maintained automatically. The rate of flow of the milk and the width of film on a vertical, stainless steel surface was controlled while the elevation and distance of the arc from the milk film was adjustable. The variations in radiant energy impinging on the film depend on the solid angle of radiation intercepted by the surface. This is conceived as a rectangular pyramid with apex at the center of the arc and base delineated by the limits of the rectangular surface. To determine the most suitable solid angle, the film travel distance, length of vertical angle, and film width of horizontal angle, were independently varied. The effectiveness of the irradiation was measured by bioassay methods.

Distances of the arc of 4, 6, 8 and 10 inches from the center of the film were used with emission rates producing intensities in wave lengths of less than 3000 A° of 1000, 2000, 4000 and 6000 microwatts measured at a distance of 8 inches horizontally opposite the center of the arc. The plan permitted the variation of radiation intensity while applying a constant amount of energy within the fixed solid angle of radiation. Experiments

were conducted with four rates of milk flow with each of four rates of energy emission at each of four distances from the arc. Both fresh milk and homogenized evaporated milk were studied.

The effect of varying the horizontal and vertical angles was found to be an increase of vitamin D potency with an increase in vertical angle of radiation up to 100° and a decrease in potency as the horizontal angle is widened beyond 60°. Hence, the effective solid angle of radiation for these experiments was defined as one having 90° vertical and horizontal angles. Limiting the applied radiations in this manner, 6 inches proved to be the optimum distance between arc and film for maximum potency, independent of intensity and film capacity. It is assumed that other little-known factors are involved in determining the effectiveness of this 6 inch distance.

The vitamin D potency bears a parabolic relationship to the amount of radiant energy applied. Analyses of the data reveal that, for any given distance between arc and film, identical variations in the amount of applied energy, however produced, have identical effects measured in terms of vitamin D potency of the milk. This holds true even for successive exposures of the milk. This leads to the generalization that irradiation of flowing films of milk with a given radiation source at a given distance from the film produces an antirachitic potency dependent upon the number of successive exposures, the film capacity, and the radiation intensity, only insofar as these affect the amount of applied energy.

From their data the authors derive a mathematical expression for the potency-energy relations as follows:

$$P = KA^{1/n}\frac{I^{1/n}}{Q^{1/n}} \text{ where}$$

I = intensity
A = area of milk film
Q = quantity discharge per unit time
K = a constant
1/n = decimal exponent in equivalent fraction, ranging between 0.5 and 0.6

Allowing for maximum deviations of 10 per cent in I and Q, the variations in potency of the milk will lie within the limits of accuracy of the bioassay method.

Since the film capacity-potency relation is hyperbolic and the intensity-potency relation is parabolic, it is desirable to employ sufficiently high intensities and film capacities to avoid excessive variations in potencies. Present commercial equipment satisfies the limitations developed by these investigators. J.H.N.

Other abstracts of interest are numbers 372, 374, 375, 376, 379, 393, 394, 395, 396, 397, 398, 399, 401, 403, 459, 463 and 464.

MISCELLANEOUS

456. Cold Storage Locker Plants. Marvin A. Schaars. Univ. of Wisconsin, Madison, Wis. Nat. Butter and Cheese Jr. Article I, *29*, 11, p. 6, June 10th, 1938; Article II, *29*, 12, p. 6, June 25, 1938.

Article I. About 90 per cent of approximately 2,000 cold storage locker plants have been built since 1936. They are operating in northern and western states chiefly, but are reported in at least twenty-one states. Some provide cold storage space only; others furnish a butchering service which includes butchering, chilling, cutting, wrapping, grinding, smoking, curing, and the like. The modern plant provides rooms for chilling, ageing, cutting, sharp freezing and lockers. Investment in refrigerating machines, insulation, lockers and equipment fully installed, and for land and building total approximately \$25.00 to \$35.00 per locker in plants with 200 to 500 lockers. Limited information on cost of operation makes it possible to estimate an approximate cost per year of \$11.46 and \$10.62 per locker in complete service plants of 300 and 500 locker capacities, respectively. This cost is exclusive of interest on investment. Earning capacities of locker plants are discussed and estimates are shown that suggest a net return on the investment approximately 10 per cent.

Article II. Locker plants may be licensed by the state in which they operate. Plants may be operated in conjunction with some other enterprise, such as cheese factories, creameries, ice plants, meat markets and grocery stores. Locker plants may be either privately or cooperatively owned and operated. An ideal location is a thriving small town up to 5,000 population which is surrounded by a thickly populated farming area. Successfully operated city plants indicate that operations are not restricted to rural communities. Existing plants draw 75 to 85 per cent of their patronage from farmers. The permanency of the locker system can be assured if it provides an economical, attractive service that fits in with the modern household economy. W.V.P.

457. A Trial with Tempoary Silos. W. E. Krauss, C. C. Hayden, A. E. Perkins and R. G. Washburn. Ohio Agric. Exper. Sta., Wooster, Ohio. Ohio Bimonthly Bull. Vol. XXIII, No. 192, May–June, 1938.

Second cutting alfalfa was put up in temporary silos of the snow fence type. The material in one silo was untreated; molasses at the rate of 2 per cent was added to that of a second; and the A. I. V. treatment was applied to the alfalfa put into a third silo. Much spoilage occurred in all three silos, particularly at the top and around the edges. Carotene preservation was best in the molasses-treated material. In a palatability trial cows preferred corn silage to alfalfa silage. The carotene content of the milk pro-

duced varied in accordance with the carotene content of the silage. Suggestions and precautions concerning the use of temporary silos are given, chief of which is that temporary silos are probably best adapted to storing a late crop for feeding in the fall or early winter to supplement and extend the use of a permanent silo. W.E.K.

458. Protein Production Increased by Liming. E. E. BARNES, Ohio Agric. Exper. Sta., Wooster, Ohio. Ohio Exper. Sta. Weekly Press Bull. No. XXIII–18, July 7, 1938.

A 3-year rotation of corn, small grain, and hay (red clover, mammoth clover, alsike clover, sweet clover, alfalfa, soybeans, or timothy) was followed on soil limed to the neutral point and on unlimed soil with a pH of 5.0. On an average, liming to the neutral point increased the yield of dry matter 77 per cent and the protein 112 per cent. W.E.K.

459. A. I. V. Silage. H. T. GREENE and H. OTTERSON, Brook Hill Farm, Genesee Depot, Wis. Cert. Milk *13*, 144, p. 9, April 1938.

This paper deals largely with a review of recent investigations as to values found in A.I.V. silage. The following subjects are discussed in connection with A.I.V. silage: Grass juice factor, use of different acids in the manufacture of carotenoids, and proteins and nitrogen compounds. W.S.M.

460. Eleventh World's Dairy Congress. A. C. DAHLBERG, New York Exp. Sta., Geneva, New York. Ann. Conv. Intern. Assoc. Milk Dealers, Laboratory Section, P. 79. 1937.

The author reports an attendance of 3,760 from 53 countries of which slightly less than half were from Germany, the congress meeting in Berlin. Seventy-two registered from U. S. A brief digest is given of many of the noteworthy papers, particularly those which dealt with milk from the standpoint of sanitation, disease control, composition and flavor, quality control, nutritive value and methods of processing. It was noted that the reports dealt largely with problems under European conditions. E.F.G.

461. Cooperative Experiments in Pasture Improvement. D. R. DODD, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Bimonthly Bull. 23, No. 191: p. 39, 1938.

This is a progress report of results obtained from 1931 through 1937 in experiments with fertilizers on pasture situated at many points throughout Ohio. Best yields of both total and desirable herbage were obtained when combinations of superphosphate and sulfate of ammonia, or superphosphate, muriate of potash, or sulfate of ammonia were used. Equivalent production and returns also favored these treatments.

The relative amount of white clover in the pasture was found to influence

herbage yield and possible returns. Phosphate alone lowers the cost and greatly increases the returns where a high clover content can be maintained. Nitrogen in addition has little effect on returns and greatly increases the cost. when clover can not be grown the addition of nitrogen is effective.

These tests are cited as evidence to justify the general improvement of adapted permanent pasture lands. W.E.K.

462. **Management Factor in Pasture Improvement.** D. R. DODD, Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. XXIII 4, March 31, 1938.

Experiments in which different heights and frequency of clipping were practiced showed that short, frequent clipping affected adversely the yield and character of the herbage. Controlled grazing, mowing, or both, are suggested for keeping the growth of herbage under control. W.E.K.

463. **Can Make Good Silage of Certain Hay Crops.** Dairy Dept., Ohio Agr. Exp. Sta., Wooster, Ohio. Ohio Exp. Sta. Weekly Press Bull. No. XXIII–8, Apr. 28, 1938.

Good silage can be made from such hay crops as alfalfa, clover, and soybeans, or mixtures of these with grasses or corn. The use of molasses for legumes is recommended. W.E.K.

464. **Industry's Responsibility in Labor Relations.** C. A. JAY, Dallas Open Shop Association. Ann. Conv. Intern. Assoc. Milk Dealers, General Sessions, p. 83, 1937.

The effects of the National Labor Relations Act in prevention of strikes which is stated as one of its objects, can be judged by the fact that in the four years, 1933–1936 inclusive, the number of workers involved in strikes was 299 per cent greater than in the four years, 1929–1933 inclusive, and the number of man-days lost was 152.5 per cent greater in the latter period. Ignorance of the National Labor Relations Act and disregard of its provisions has resulted in confusion. Every employer should know what the act requires and what it does not. The writer proceeds to explain many of the more important provisions of the Act as they specify employer-employee relations and what each can and cannot do. No single piece of legislation heretofore proposed, has had such far-reaching potential consequences as that to fix wages and hours of labor in American industry.

The author states that he believes such a law is undesirable because it is impossible of accomplishment. He then outlines the basis of such a law if it is granted that it is inevitable. He recommends first that labor problems be a major subject for study by the Association and second, that a better understanding between employer and employee be developed. The milk industry cannot indiscriminately increase the cost of its product in order to

meet wage scales which are out of line with the earnings of the average customer of this industry. E.F.G.

465. Getting Maximum Results from the Refrigerating System. H. A. RUEHE, Dept. of Dairy Husbandry, Univ. of Ill., Urbana, Ill. Ice Cream Rev. *21*, 10, p. 104, May 1938.

Some of the factors which affect efficiency in refrigerating machinery and which any operator can remedy are given. J.H.E.

466. Storage Lockers for Revenue. ANONYMOUS. Ice Cream Field *32*, 5, p. 20, April 1938.

It is pointed out that many cold storage plants now provide rented lockers in which tradesmen and others may store perishables.

The opportunity of supplying this service in smaller towns is open to many ice cream manufacturers, milk dealers, creamery men and cheese factory operators equipped with cold storage facilities. W.C.C.

PHYSIOLOGY

467. The Effect of Sympathectomy on Gestation and Lactation in the Cat. F. A. SIMEONE and J. F. ROSS, Department of Physiology in the Harvard Medical School. Am. J. Physiol. *122:* 3, 659, 1938.

Observations are reported on gestation, parturition and lactation in totally and partially sympathectomized cats shortly after completion of the surgical procedures and a year later. The incidence of abortions is high in animals that become pregnant shortly after sympathetic denervation of the internal genitalia. The incidence of stillbirths is high in animals that become pregnant long after sympathectomy. Sympathetic denervation of the mammary glands caused definite variation from normal functioning activity, recognizable histologically, in only 1 out of 7 pregnancies that went to term. D.L.E.

468. The Effect of Thyroxin on the Carbohydrate Metabolism of Hypophysectomized Rats. JANE A. RUSSELL, Institute of Experimental Biology, Univ. of California, Berkeley. Am. J. Physiol., *122:* 3, 547, 1938.

Thyroxin substitution therapy in hypophysectomized rats can restore the rate of absorption of glucose from the intestine completely to normal. The dose of crystalline thyroxin necessary for this action is less than that required to restore the metabolic rate. This treatment does not improve the maintenance of carbohydrate stores during the fasting or change the proportionate disposition of absorbed glucose in hypophysectomized rats. D.L.E.

469. Pancreatectomy in the Goat. F. D. W. LUKINS and GEORGE S. COX, Medical Research Institute, Univ. of Pennsylvania, Philadelphia. Am. J. Physiol. *122:* 729, 1938.

Four young goats were depancreatized. Following pancreatectomy, the goat has a mild type of diabetes as measured by the extremely low glycosuria and low, although increased, nitrogen excretion. Unlike the cat, dog and pig, ketonuria is slight or absent.

Explanations are offered to explain why depancreatized goats manifest a certain ability to utilize carbohydrate, as shown by two animals in which glucose was given intravenously, and only 25 to 50 per cent excreted. Even when the sugar was given by stomach tube, no sugar could be aspirated a few hours later. The assumption is made that glucose is fermented or otherwise transformed in the herbivorous stomach and absorbed in some non-reducing form. D.L.E.

470. Factors Determining Voluntary Ingestion of Water in Normals and in Individuals with Maximum Diabetes Insipidus. CURT P. RICHTER, Psychobiological Laboratory, and Henry Phipps Psychiatric Clinic, Johns Hopkins Hospital, Baltimore, Md. Am. J. Physiol, *122:* 668, 1938.

The voluntary water intake of normal animals and humans was found to be a function of surface area rather than of body weight, and hence must be a function of metabolism. The average daily intake per square meter body surface varied from 1,050 cc. to 1,238 cc. in rats, cats, dogs, monkeys, and humans, averaging 1,142 cc.

The maximum voluntary water intake in animals with diabetes insipidus was found to be a function of body weight rather than of body surface. The regulatory action of the posterior lobe secretion on the maintenance of the water balance is described. It was suggested that the level of the maximum intake with diabetes insipidus might be determined by the maximum capacity of the kidney or by the maximum capacity of all the cellular spaces of the body, both of which would be functions of body weight. D.L.E.

471. The Effects of Inanition on Temperature Regulation. GEORGE CLARK, Institute of Neurology, Northwestern Univ. Medical School. Am. J. Physiol., *122:* 646, 1938.

Normal well-nourished cats when placed on an inadequate diet react normally to cold until the weight loss considerably exceeds 30 per cent. The rectal temperature of cats, which have lost considerably more than 30 per cent of their original weight as a result of an inadequate diet, drops to extremely low levels upon exposure to cold.

The responses to heat are not interfered with by weight losses which cause abnormal responses to cold. D.L.E.

472. **A Simple Apparatus for Milking Small Laboratory Animals.** P. L. TEMPLE and J. K. KON, National Institute for Research in Dairying, Univ. of Reading. Biochem. J. *31:* 2197, 1937.

A diagrammatic discussion of the instrument is presented. K.G.W.

473. **The Utilization of Lactic Acid by the Lactating Mammary Gland.** W. R. GRAHAM, JR. Dept. of Dairy Husbandry, Univ. of Mo., Columbia, Mo. J. Biol. Chem. *122*: 1, 1937.

The experiments show that considerably more lactose was being secreted than could be accounted for by the removal of glucose from the blood and that other carbohydrate-forming compounds must be taken up by the gland. Glucose, lactic acid, and amino nitrogen are removed from the blood in substantial amounts. Eighty-five per cent of the lactose formed during the experimental period could be accounted for theoretically from glucose and lactic acid from the blood, the remaining 15 per cent may be accounted for if the amino nitrogen removed from the blood is calculated as a 3-carbon amino acid, which may be converted into lactic acid. Because experiments indicate lactic acid is produced rather than absorbed by the gland, this acid may be an important precursor of lactose of milk. K.G.W.

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JOURNAL OF DAIRY SCIENCE

VOLUME XXI | OCTOBER, 1938 | NUMBER 10

RIBOFLAVIN CONTENT OF MILK COLLECTED IN DIFFERENT MONTHS AND CORRELATED WITH OTHER CONSTITUENTS OF THE MILK[1]

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Interest in variations of the riboflavin content of milk is a natural consequence of previous indications that d-ribose may be isolated from whey (10). The availability of a rapid method for the determination of riboflavin in milk (13) offers opportunity for extensive studies of the amount of this substance in milk. Biological determinations at this station (7) have shown colostrum to be richer in flavin than milk produced later in lactation. Such determinations have also suggested that the amounts of riboflavin in samples from groups of different breeds on widely different rations vary within a comparatively narrow range. The purpose of this study was to apply the rapid method of riboflavin determination to samples of normal milk collected at intervals from individual cows of different breeds on different rations; and to compare these values with the seasons and the cows involved; and with the concentrations of various other constituents in the milk.

PROCEDURE

Samples were procured from each milking of each cow in the station herd on 3 successive days in March, April, May, and July.[2]

The animals used included 4 breeds. A group of young Holsteins on a special ration which had never included pasture, and a group including all breeds which for two periods of six weeks each was fed a ration low in carotene, were also studied. The regular ration included Atlas sorgo silage, alfalfa hay, and a grain mixture of yellow corn, bran, and cotton seed meal. The ration for the experimental Holstein group differed in that white corn was used in the grain mixture and that prairie hay replaced the alfalfa, or for some cows, both the alfalfa and silage. During the time the flavin tests were made, the low carotene ration included wheat straw, cotton seed meal

[1] Contribution No. 227, Department of Chemistry, and No. 78, Department of Food Economics and Nutrition.

[2] The samples were supplied by Professor H. W. Cave of the Department of Dairy Husbandry and were used for several projects in which the Departments of Chemistry and Dairy Husbandry were cooperating.

and molasses. Earlier in the year a grain mixture of yellow corn and bran had been fed the more heavily producing cows of this group. Shortly before the May samples were collected, limited amounts of pasture were provided for all cows except the experimental Holsteins. Pasture later became abundant so that all except the experimental Holsteins received a generous pasture supplement before the July samples were collected.

The determinations for flavin (13), vitamin C (14), and phosphatase (6) were made on morning milks only and on the days the samples were collected. The determinations for total solids[3] (1), fat[3] (1-Babcock), fat color (11), lecithin (4), protein chlorine[3] (8), and lactose (1) were made on composites for each cow of each milking of each 3-day period. The value for protein was obtained by subtracting from the total solids, the sum of the measured values for fat and lactose and an assumed value of 0.75 per cent for ash. All fluorimetric readings for flavin were made jointly by 2 or sometimes 3 observers. The microscopic tests[4] for leucocytes, and for mastitis streptococci, and other forms of bacteria were made on samples of fore milk from small groups of cows at intervals of 2 to 4 weeks. The method of calculating mastitis scores from these tests is described elsewhere (12). The results of these microscopic tests were interpolated to the times at which chemical analyses were made. Comparisons[5] of flavin with breeds, seasons, mastitis, and constituents measured on 3-day composite samples were based on 3-day average values for flavin. Comparisons with constituents measured daily were on the basis of daily values.

RESULTS

The relations of flavin to breeds, stages of lactation, and seasons are shown in tables 1 to 3 respectively. The flavin content of milk from none of the straw fed cows appeared unusual for the breed concerned, or in relation to later values on the same cow. Values for these milks were, therefore, included with the milk from normally fed cows. The average flavin content of milk increased significantly from Ayrshires to Holsteins, from Holsteins to Guernseys, and from Guernseys to Jerseys. (See table 1.) While the experimental Holsteins produced milk with slightly more flavin than the regular Holsteins, this difference is probably not significant.

The average differences in flavin content of milk samples collected from any one breed of cows, either ½ to 5 months, or 5 to 10 months after the cows

[3] These determinations were made by Mr. W. J. Caulfield of the Department of Dairy Husbandry.

[4] These tests were made by Dr. A. C. Fay and Mr. V. D. Foltz of the Department of Bacteriology as part of a project in which they were cooperating with the Department of Dairy Husbandry.

[5] The authors acknowledge the assistance of (a) Mr. H. H. Laude of the station staff, and Prof. M. C. Moggie of Kansas State College, (b) Dr. George W. Snedecor of the Statistical Laboratory of Iowa State College in making these comparisons.

TABLE 1

Flavin content of milk from different breeds of cows

Breed	No. of 3-day periods Mar., Apr., May	Flavin content p. p. m.	S.E. of means
Experimental Holsteins	41	1.43	.053
Ayrshires	34	1.17	.036
Regular Holsteins	45	1.37	.043
Guernseys	38	1.53	.048
Jerseys	47	1.73	.042

TABLE 2

Flavin content of milk in relation to stage of lactation by breeds

Breed	Cows No.	Tests No.	State of lactation months	Flavin content	
				Cows p. p. m.	Tests p. p. m.
Experimental Holsteins	9	21	½ to 5	1.24	1.45
	4	10	5 " 10	1.35	1.35
Regular Holsteins	11	16	½ to 5	1.29	1.39
	8	20	5 " 10	1.38	1.38
Ayrshires	8	17	½ to 5	1.16	1.16
	6	16	5 " 10	1.16	1.15
Guernseys	4	10	½ to 5	1.54	1.49
	7	23	5 " 10	1.51	1.53
Jerseys	10	12	½ to 5	1.60	1.57
	11	31	5 " 10	1.58	1.78

freshened, were so small as to be considered negligible. Averages for each stage of lactation in each group of cows were calculated both on the basis of single tests, and also on the basis of averages for each cow in the stage and group. On either basis the flavin content of milk was higher in the first stage of some groups and in the last stage of others.

Although the mean flavin content of milk increased for all the breeds from May to July (see table 3) it is doubtful whether this increase should be ascribed to the change in rations. If pasture produced the increase, it should have started in May. For Guernseys there was in May an increase of some significance, while the experimental Holsteins were the only herd to show a significant decrease at this time. The changes in the other three breed groups were very small. It might be argued that a longer time was needed for pasture to produce the expected rise in flavin. The July values indicated significant rises for only the Guernseys and experimental Holsteins. The flavin increased much more for the experimental Holsteins that received no pasture, than for any other group except the small herd of Guernseys.

The coefficients of correlation between concentrations of flavin in the

TABLE 3

Changes in the riboflavin content of milk produced in different months

Cows used as sources of milk	Date of collection of samples	Average change in flavin p. p. m.	Critical* ratio of change	Coefficients of correlation
15 Experimental	Mar. and Apr.	−0.23	1.51	+0.18
11 Holsteins	Apr. " May	−0.12	3.6	+0.85
9	May " July	+0.23	2.8	+0.07
11 Regular	Mar. and Apr.	−0.07	1.05	+0.64
15 Holsteins	Apr. " May	+0.06	0.95	+0.68
11	May " July	+0.02	0.17	+0.57
9 Ayrshires	Mar. and Apr.	−0.09	0.77	−0.40
10	Apr. " May	−0.00	0.04	−0.48
9	May " July	+0.04	0.51	−0.35
12 Guernseys	Mar. and Apr.	−0.07	0.39	−0.03
12	Apr. " May	+0.25	2.2	+0.00
6	May " July	+0.18	4.6	+0.87
16 Jerseys	Mar. and Apr.	+0.02	0.24	+0.45
15	Apr. " May	+0.05	1.00	+0.49
10	May " July	+0.15	1.2	+0.58

$$* \frac{\text{Change}}{\sqrt{\dfrac{s^2x + s^2y - 2sxsy}{N}}}$$

See:
G. U. Yule, Introduction to Theory of Statistics Ed. 5 p. 211. Griffth.
G. W. Snedecor, Statistical Methods. p. 132. Collegiate Press, Ames, Ia.
G. E. Garrett, Statistics in Psychology and Education. p. 287. Longmans.

milk of given cows on successive months furnish an important measure of the significance of the changes in average values (14). The large variations in these correlations (see last column of table 3) indicate that the causes of variation were not uniform. The variations of climate and ration, which were uniform for all cows were, therefore, certainly not the only important factors which caused the variations in the flavin content of the milk. The Guernseys and Ayrshire breeds showed more irregular correlations, and less consistent relations of flavin to fat than the other three groups.

The relation of flavin to milk yield was found very variable and a helpful discussion of this relation must await further study. Relations of the flavin content of milk to the concentrations of 12 other constituents in the milk are shown in table 4.

The fat is the only one of these constituents for which there was anywhere near a consistent, significant relation in the total group of comparisons made. Effects of season, age of cow, stage of lactation, etc., may later be found to have some significant relations. These effects were found to be unimportant for the relation between flavin and fat. Average values of these constituents for each cow are shown in figure I. In each group except Guernseys there appears to have been a significant positive correlation be-

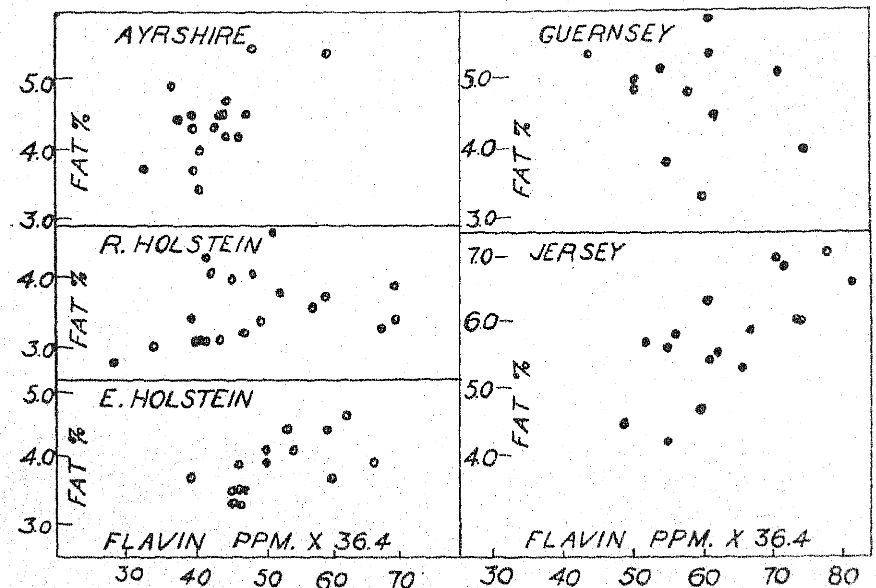
TABLE 4

Relations of flavin to other constituents of milk in spring and summer months

Breed	N	r	CR*	N	r	CR	N	r	CR	N	r	CR
	Vitamin C per cent of milk 3, 4, 5/37			Loss of C. 72 hrs. at 4° C. 3/37			Carotene per cent of fat 3, 4, 5/37			Lecithin per cent of fat 3/37		
Experimental Holsteins	114	−.025	.26	28	−.314	1.69	35	−.203	1.20	11	−.248	
Regular Holsteins	125	−.145	1.63	36	−.505	3.41	45	−.145	.98	11	−.092	
Ayrshires	96	−.064	.63	36	−.134	.80	33	−.088	.50	11	−.018	
Guernseys	98	−.063	.67	31	−.132	.73	38	−.286	1.80	13	−.483	
Jerseys	136	−.403	5.10	46	−.121	.82	53	−.160	1.68	15	−.166	
	Fat 3, 4, 5, 7/37			Protein 3, 5, 7/37			Lactose 3, 5, 7/37			Phosphatase 3, 4, 5/37		
Experimental Holsteins	51	−.404	3.65	35	−.210	1.25	36	−.014	.08	103	−.048	.49
Regular Holsteins	59	−.352	2.80	41	−.034	.22	44	−.016	.10	116	−.148	1.82
Ayrshires	44	−.437	3.15	35	−.118	.69	37	−.110	.67	92	−.206	2.02
Guernseys	40	−.240	1.55	31	−.199	1.12	32	−.013	.07	95	−.354	3.65
Jerseys	57	−.490	4.15	38	−.246	1.59	38	−.231	1.39	127	−.250	2.91
	Leucocytes 3, 4, 5/37			Streptococci 3, 4, 5/37			Odd bacteria 3, 4, 5/37			Chlorine 3, 4, 5, 7/37		
Experimental Holsteins	39	−.220	1.38	39			39	−.161	1.00	51	−.060	
Regular Holsteins	45	−.242	1.63	45	−.328	2.20	45	−.230	1.55	59	−.160	
Ayrshires	33	−.554	3.70	33	−.245	1.41	33	−.296	1.73	44	−.030	
Guernseys	38	−.109	.67	38	−.105	.64	38	−.090	.55	40	−.116	
Jerseys	47	−.096	.66	47	−.435	3.20	47	−.190	1.32	58	−.180	

* $CR = \frac{r(N-2)^{1/2}}{(1-r^2)^{1/2}}$. George W. Snedecor, Statistical Methods 1937 Edition, Page 125, Collegiate Press Inc., Ames, Iowa.

FIGURE I FLAVIN AND FAT IN MILK FROM COWS OF DIFFERENT BREEDS



tween flavin and fat content. The apparent negative relation for Guernseys may be due to the small number of cows tested. If real, it would be a more serious exception to the relation in other groups if these Guernseys were not also exceptional in the relations of lecithin, and phosphatase to flavin. The authors have at present no explanation for this possible unusual behavior of the Guernsey group, but the distinctive relation of flavin to three different constituents, indicates considerable probability that either Guernseys as a breed, or this particular group, were unusual.

That the fat, which is in an entirely different phase of the milk from the flavin, was the only constituent to which the flavin was regularly related is indeed surprising. There is, however, evidence that flavin functions in combination with protein (9), and that milk-fat is synthesized from carbohydrates derived from proteins or amino acids (5). If flavin plays a rôle in fat synthesis, it would not be surprising that the disturbance of this rôle among Guernsey cows was associated with unusual relations of flavin to lecithin and phosphatase. Both the flavin and phosphatase values were subject to large daily variations. While some of the variations in fat and lecithin were lost in the use of composite samples, it is generally accepted that fat, at least, is also one of the most variable constituents of milk. The variation of lecithin is less known, but from the values summarized in table 4 and from other values on samples for which flavin was not measured (2, 4), we may expect this variation to be as great as for fat. Little or nothing

is known of the rôle played by either flavin, phosphatase or lecithin in the synthesis of milk fat. They would all be classed among the active or unstable constituents of milk and might therefore be involved in this synthesis.

SUMMARY

Riboflavin determinations were made on samples of milk collected at intervals from individual normal cows of different breeds and on different rations. The influences of season and individuality on flavin values were considered. The relationship of flavin content to the concentrations of the following constituents in the milk were tested: vitamin C, loss of C on 72 hours storage at 4° C, carotene, lecithin, fat, protein, phosphatase, leucocytes, mastitis streptococci, odd bacteria, lactose, and chlorine.

The average flavin contents in March, April, and May were for Ayrshires 1.17 parts per million, for Holsteins 1.37, for Guernseys 1.53, and for Jerseys 1.73. Milk from cows between 15 days and 10 months after freshening, showed no significant difference in flavin content.

The flavin content of milk was slightly higher in July after the cows had been pastured. The climate and ration were not the only important factors which caused variations in the flavin content of milk.

The fat is the only constituent of milk for which an approach to a significant consistent relation to flavin was found. It is suggested that flavin may have a rôle in the production of milk fat.

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BOUND WATER AND ITS RELATION TO SOME DAIRY PRODUCTS

III. THE RELATION OF BOUND WATER TO SOME DAIRY PHENOMENA[1]

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Previous studies have shown that liquid dairy products contain appreciable amounts of bound water (1) and that the bound ⇄ free water equilibrium may be changed by certain treatments (2). Since milk and other dairy products contain a colloidal complex, it was thought desirable to investigate certain dairy phenomena from the standpoint of hydration.

EXPERIMENTAL METHODS

The samples and methods used were, on the whole, as previously described (1). Although in certain experiments changes in samples and methods were made, these changes will be dealt with under the sections reporting the experimental work.

POSSIBLE RELATION OF BOUND WATER CONTENT TO THE CREAMING OF MILK

The gravity formation of a maximum cream layer on bottled milk is of considerable importance in the market milk industry, largely because of the layman's method of judging richness. The processor of milk knows in a general way the factors affecting creamline but does not understand exactly why heat treatment is destructive to creamline. It was to supplement the existing knowledge of the creaming of milk that this work was undertaken in the hope that further explanation would be obtained.

The inhibited creaming of heated milk has attracted attention ever since pasteurization was first accepted as a general practice in the milk industry and much has been written in attempting to explain this phenomenon. Rahn (3) showed that the creaming property can be restored after heating by the addition of gelatin or other accelerating colloids. Van Dam and Sirks (4) added to milk such colloids as gelatin, starch, Irish Moss and gum tragacanth and obtained a 15–25 per cent increase in volume of cream, and postulated that fat clumping took place. Babcock and Russell (5) and others found that the presence of fat clumps was essential to creaming.

Palmer and Anderson (6) believed that the plasma colloids were of con-

Received for publication March 18, 1938.

[1] Authorized for publication on March 11, 1938, as paper No. 827 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] The data presented in this paper are from a thesis submitted to the Graduate School of The Pennsylvania State College in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1937.

siderable importance in the creaming of milks of uniform fat content. They stated that the calcium caseinate was a factor in creaming, and thus it was affected by pasteurization temperatures. The whey colloids, which are greatly hydrated, are effective promotors of cream rising. These investigators state further that "Both exhaustiveness of rise of fat and greater volume of cream are promoted by the truly hydrophilic colloids and depressed by colloids of hydrophobic properties."

Therefore it might be that the effect of heat on creaming centers around the plasma colloids to a certain degree. The conditions and the forces acting at the fat/plasma interface may also be of importance. A truly hydrophilic colloid added to milk gives a quicker cream rise, a larger cream layer of lower fat content, and a plasma of lower fat content. The increase in viscosity of milk by non-colloids like sugar delays creaming (3).

The chief stability factor of a hydrophilic colloid is its degree of hydration. The fat globule membrane is composed chiefly of phospholipids and protein. That the phospholipids are greatly hydrophilic has been previously shown (1). It is also known that the casein of milk owes its stability to charge and hydration. With this information a series of experiments were made to determine the relationship between high heat treatment, bound water content, and the creaming ability of milk.

Three experiments were conducted as follows: (1) Raw whole milk was heated in a water bath to different temperatures and held for various lengths of time. (2) Raw cream was added to skimmilk which had been heated to various temperatures. (3) Raw skimmilk was added to cream which had previously been heated to various temperatures. In each case unheated samples were used as controls and all samples came from the same source. The temperatures used were 143° F. for 30 minutes, 160° F. for 5 minutes, and 180° F. momentarily. After the skimmilk or cream was heated, it was cooled to approximately 80° F. before reconstituting. Samples for creaming were stored at 38° F. in 100 ml. graduated cylinders and examined after 24-hour intervals. The results are expressed as percentage cream volume per one per cent fat.

The results of these experiments are recorded in Tables 1, 2 and 3. Table 1 shows the effect of heat on the creaming ability and bound water content of fresh whole milk. Table 2 shows the effect of heat on the creaming ability and bound water content of whole milk prepared from heated skimmilk to which fresh raw 48 per cent cream was later added. Table 3 shows the effect of heat on the creaming ability and bound water content of whole milk prepared from heated 54 per cent cream to which raw skimmilk was later added.

Pasteurization of whole milk at 143° F. for thirty minutes, if done correctly, has very little effect on the creaming ability of the milk. The bound water reduction was slight when compared to higher heat treatments. At

TABLE 1

The effect of heat treatment on the creaming ability and bound water content of fresh raw milk

Treatment	Hours aged at 40° F.	Per cent solids	Alcohol No.	Viscosity centipoises	Volume cream layer per one per cent fat	Per cent bound water	Per cent decrease in bound water content due to heating
1. Unheated	24	11.92	8.1	2.204	4.23	3.75	....
2. Heated to 143° F. for 30 min.	24	12.09	9.1	2.102	4.06	3.56	5.6
3. " " 160° F. for 5 "	24	11.94	9.3	2.041	0.77	3.06	18.4
4. " " 180° F. for 0 "	24	12.11	9.3	2.061	0.76	3.30	12.0

TABLE 2

The effect of heat treatment on the creaming ability and bound water content of reconstituted milk (heated skimmilk plus raw cream)

Treatment	Hours aged at 40° F.	Per cent solids	Alcohol No.	Viscosity centipoises	Volume cream layer per one per cent fat	Per cent bound water	Per cent decrease in bound water content due to heating
1. Unheated	24	12.43	7.6	2.122	4.11	3.41	....
2. Skimmilk heated to 143° F. for 30 min.	24	12.19	8.0	2.061	3.00	3.11	8.8
3. Skimmilk heated to 160° F. for 5 min.	24	12.24	8.3	2.241	0.72	2.45	28.1
4. Skimmilk heated to 180° F. for 0 min.	24	12.38	8.3	2.306	0.64	2.29	32.8

TABLE 3

The effect of heat treatment on the creaming ability and bound water content of reconstituted milk (heated cream plus raw skimmilk)

Treatment	Hours aged at 40° F.	Per cent solids	Alcohol No.	Viscosity centipoises	Volume cream layer per one per cent fat	Per cent bound water	Per cent decrease in bound water content due to heating
1. Unheated	24	12.71	7.5	2.163	4.00	3.38	....
2. Cream heated to 143° F. for 30 min.	24	12.55	7.5	2.102	3.79	3.22	4.0
3. Cream heated to 160° F. for 5 min.	24	12.67	7.6	2.082	3.58	2.80	14.5
4. Cream heated to 180° F. for 0 min.	24	12.58	7.6	2.000	3.46	2.64	19.0

the higher temperatures there was a more marked reduction in bound water content and the volume of the cream layer was also greatly reduced.

Table 2 shows that the heating of the skimmilk alone and subsequent adding of fresh cream to it to make a normal milk, gives results similar to those obtained when whole milk is heated except that the reduction in the cream layer and bound water content is much greater.

The heating of the cream to high temperatures does not have a marked effect upon the cream layer although the bound water content of the reconstituted milk was noticeably reduced but not as much as when the plasma only was heated. Apparently when the cream is heated there is a reduction in the bound water content of the hydrophilic fat globule membrane of the cream. From these experiments it might be said that the bound water content of milk colloids does not affect greatly the creaming ability of the milk. The greatest reduction in creaming was obtained in the samples containing the greatest reduction in bound water content it is true, but the differences in bound water reduction shown in Tables 1 and 3 do not indicate any relation to creaming ability exhibited in the same samples.

THE RELATION OF BOUND WATER CONTENT TO THE SPECIFIC GRAVITY OF MILK

Freshly drawn milk invariably shows an increase in specific gravity on standing. This is commonly referred to as Rechnagel's phenomenon. Rechnagel (7) associated this change with an increase in the hydration of the proteins. He did not study skimmilk. Quevenne (8) also thought that changes in protein hydration were concerned. Toyonaga (9) obtained results that show that a change in specific gravity was due to volume changes when the fat solidified and that the change did not occur in skimmilk. Fleischman and Wiegner (10) obtained the density increase when milk was held at 15° C. and confirmed the results of Toyonaga. Fleischman (11) observed that the changes of volume of milk with temperature changes are greater than for water. These changes with temperature are attributed principally to variation in hydration of the proteins.

Davies (3) attributes the increase in density on standing to: (1) changes in the specific gravity of the fat due to cooling and partial solidification; (2) hydration of the proteins; and (3) loss of carbon dioxide. Sharp and Hart (12) state that previous temperature history of the milk influences its specific gravity at 15° C. and that this variation is due to the physical state of the fat.

Rechnagel (7) found that the rise in density is regular, and is more rapid at low than at high temperatures and amounts to 0.001. Richmond (13) found the average change to be 0.0006 with a variation from 0.0003–0.0015 and attributes this largely to the increase in density of the fat on solidification. He further states that the effect does not vary seasonally

but may vary with milk from individual cows or from one sample to another.

Freshly drawn mixed milk was used to note if the change in specific gravity was accompanied by a change in bound water content on standing. The milk was quickly cooled in ice water to 40° F. after processing and several experiments were conducted. The specific gravity was determined with the Westphal balance at 15° C. The milk was divided into four lots and comparisons were made of the following: (1) raw milk, freshly drawn; (2) milk heated to 143° F. for 30 minutes; (3) raw skimmilk; and (4) skimmilk heated to 143° F. for 30 minutes. To eliminate dissolved gases as a factor, lots 2 and 4 were heated, and to eliminate butter fat as a factor, experiments with skimmilk were conducted. Determinations were made on the freshly prepared samples, after holding 8 and 24 hours at 40° F. (Table 4.)

TABLE 4

The relation of bound water content to the specific gravity of milk

Sample	Hours aged at 40° F.	Per cent solids	Viscosity centipoises	Specific gravity (15° C.)	Per cent bound water
1. Raw milk	0	13.25	2.245	1.0314	2.79
	8	13.25	2.347	1.0328	2.98
	24	13.25	2.387	1.0332	3.18
2. Pasteurized milk	0	13.61	2.183	1.0323	2.48
	8	13.61	2.285	1.0338	2.71
	24	13.61	2.326	1.0340	2.71
3. Raw skimmilk	0	9.44	1.775	1.0359	1.81
	8	9.44	1.836	1.0366	2.05
	24	9.44	1.877	1.0371	2.13
4. Pasteurized skimmilk	0	9.48	1.591	1.0358	1.41
	8	9.48	1.632	1.0372	1.69
	24	9.48	1.694	1.0375	1.81

It will be noted in Table 4 that milk and skimmilk, whether raw or pasteurized, increase in specific gravity and bound water content upon standing at 40° F. The specific gravity of raw milk increased 0.0018, and in the pasteurized milk it increased 0.0017 in 24 hours. When the raw milk was pasteurized the specific gravity increased 0.0009, showing that the dissolved gases or an increase in concentration of solids may play a part in this phenomenon. The difference in specific gravity between the raw and pasteurized skimmilk samples was only 0.0001 when determinations were made on freshly prepared samples.

Results obtained indicate that there is an increase in specific gravity of raw and pasteurized skimmilk on standing which cannot be attributed to either the dissolved gases, or to the solidification of the fat globules since in the skimmilk very little fat is present. The increase was 0.0012 in the raw skimmilk and 0.0017 in the pasteurized skimmilk. The bound water studies indicate that the increase in specific gravity might be attributed to the hydration of the lyophilic colloids.

THE EFFECT OF AGE AND TREATMENT ON THE BOUND WATER CONTENT OF VACUUM DRUM DRY SKIMMILK

To note whether there were any changes in the bound water content of vacuum drum dry skimmilk on aging, samples were stored in open and closed cardboard containers. To determine the bound water content, reconstituted mixtures were made that contained approximately 24 per cent total solids. The bound water content was determined on these mixtures made from fresh dry skimmilk, dry skimmilk stored four weeks and dry skimmilk stored eight weeks at room temperature. The results of these trials are recorded in Table 5.

TABLE 5

The effect of age and treatment on the bound water content of vacuum drum dry skimmilk

Sample*	Hours aged at 40° F.	Per cent solids	Viscosity centipoises	Alcohol No.	Per cent bound water	Grams bound water per gram of solids
1	0	24.09	12.641	5.6	11.22	0.465
	24	24.09	13.530	5.4	14.72	0.611
2	0	24.52	11.160	5.4	9.26	0.377
	24	24.52	12.345	5.4	9.89	0.403
3	0	23.25	10.883	5.4	8.77	0.377
	24	23.25	11.476	5.4	8.81	0.378
4	0	24.95	8.770	5.5	9.30	0.372
	24	24.95	9.560	5.5	10.01	0.401
5	0	24.71	8.533	5.5	7.87	0.318
	24	24.71	9.402	5.5	8.87	0.358

*1. Reconstituted dry skimmilk—fresh.
2. " " " —four weeks old in closed container.
3. " " " — " " " " open "
4. " " " —eight " " " closed "
5. " " " — " " " " open "

It is evident that there is a decrease in the amount of bound water per gram of total solids as the dry skimmilk becomes older. The decrease in bound water content is more marked in the samples of dry skimmilk stored in open containers. No difference in solubility of the dry skimmilk was noticed when these samples were reconstituted. A decrease of viscosity also occurred on storage of the dry skimmilk. The protein stability was not markedly altered by the periods of storage.

THE EFFECT OF "SUPERHEATING" ON THE BOUND WATER CONTENT OF CONDENSED SKIMMILK

The thickening produced in superheated condensed skimmilk is associated with the coagulation of the calcium caseinate. To observe the effect of superheating on the bound water content, a freshly prepared sample of condensed skimmilk was obtained directly from the vacuum pan. Part of the sample was used as the control and the other part was thickened by heating

to 180° F. for 20 minutes in a water bath. The results obtained may be observed in Table 6.

TABLE 6

The effect of superheating on the bound water content of condensed skimmilk

Sample	Hours aged at 40° F.	Per cent solids	Viscosity centipoises	Per cent acid	Alcohol No.	Per cent bound water	Grams bound water per gram of solids
1. Condensed skimmilk	0	26.27	6.459	0.58	5.0	8.09	0.307
	24	26.27	7.644	0.60	5.3	10.97	0.417
2. Superheated condensed skimmilk	0	26.43	21.124	0.575	5.7	8.99	0.340
	24	26.43	23.525	0.595	5.8	10.57	0.399

Although a large increase in viscosity is characteristic of superheating, there was little change in the bound water content because of the superheating. Both samples had been previously forewarmed in the hot well at 180° F. Superheating produced a noticeable increase in the stability of the proteins as recorded by the alcohol number. The change in viscosity obtained on superheating is not due to hydration but to coagulation.

THE EFFECT OF THE INITIAL AGING TEMPERATURE ON THE BOUND WATER CONTENT OF CONCENTRATED MILK PLASMA

The initial aging temperature is known to change some of the properties of dairy products, notably the viscosity of the system. To note if there were any bound water changes, concentrated milk plasma was aged in water baths at 90° F., 70° F., 50° F. and 34° F. and the bound water content then determined.

The results show that more water is bound initially at the higher aging temperature than at the lower temperatures. Therefore the process of imbibition is slower at the lower temperatures.

From these findings, it would seem reasonable to believe that short aging periods at relatively high temperatures would give ice cream mixes characteristics similar to low temperature mixes aged for longer periods. Mueller and Frandsen (14) have shown that about one-fou[illegible] content of ice cream mixes could be saved by [illegible] for 2 to 4 hours instead of cooli[illegible] pasteurization and aging for[illegible] plants.

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TABLE 7

The effect of the initial aging temperature on the bound water content of concentrated milk plasma

Sample	Hours aged	Per cent solids	Viscosity centipoises	Per cent acid	Alcohol No.	Per cent bound water	Grams bound water per gram of solids
1. Aged at 90° F.	4	13.71	4.859	0.28	8.4	5.52	0.403
	24	....	....	....	.....	....	....
2. Aged at 70° F.	4	13.71	4.701	0.265	8.4	4.58	0.334
	24	13.71	4.859	0.260	8.4	5.38	0.392
3. Aged at 50° F.	4	13.71	4.563	0.265	8.3	4.21	0.307
	24	13.71	4.997	0.280	8.3	5.77	0.421
4. Aged at 34° F.	4	13.71	4.405	0.260	8.2	3.92	0.286
	24	13.71	4.859	0.280	8.1	5.11	0.373

THE EFFECT OF AGING AT LOW TEMPERATURES ON THE BOUND WATER CONTENT OF FLUID MILK PRODUCTS

In studying the effect of aging on the bound water content, samples were stored at 40° F. for 4 and 24 hours, after which time the determinations were made in duplicate. Approximately 40 minutes elapsed from the time the samples were obtained until the determinations were made on the fresh samples. Determinations were made again after aging for 4 and 24 hours. In the tables previously presented, the effect of aging at 40° F. is plainly seen. In all cases (Tables 4, 5, 6, 7) the samples aged at 40° F. contained more bound water than the fresh sample. Aging of the ice cream mix 12 to 24 hours has been common practice in the ice cream industry. This is done to enhance the whipping ability of the mix in the freezer. Work by Dahle, Keith and McCullough (15), Hening (16) and others have shown that approximately four hours of aging produces whipping results as satisfactory as 24 hours of aging. Viscosity studies show that much of the increase in viscosity takes place in that four-hour period.

That whipping ability might go hand in hand with bound water content is indicated in Table 8. In this table is shown also that in the mixes which were homogenized at various pressures the viscosity increase during aging is greatest in the four-hour period. The bound water content shows the greatest increase in the first four hours of aging. The increase is slight aft... THE EFFECT OF "SUPERHEAT... and it is apparent (15) that aging for the
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The thickening produced in superheated c... ...rom these mixes because of
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sample was used as the control and the other part... 4. In this case fat clump-

TABLE 8

Relationship between age of an ice cream mix, viscosity and bound water (mixes contained 14.75 per cent fat and 12.15 per cent M.S.N.F.)*

Mix No.	Pressure used	Hours aged at 40° F.	Viscosity centipoises	Per cent bound water
1	0	0	7.9	5.14
		4.0	9.12	5.56
		24.0	8.8	5.29
2	1500	0	12.9	2.43
		4.0	14.1	3.22
		24.0	14.7	3.79
3	3000	0	45.3	1.96
		4.0	52.4	2.23
		24.0	53.23	3.47
4	3000 and 700	0	10.5	5.65
		4.0	12.8	5.93
		24.0	12.4	6.18

* No gelatin or sugar was used in mix.

ing was destroyed while in the other homogenized samples much clumping took place.

Cream and other products show an increase in bound water content on aging. Previous work (1, 2) shows that fresh raw cream increased about 16 per cent in bound water on aging, while pasteurized cream increased approximately 30 per cent. Heavy cream increases more in bound water on aging than does light cream. The substances associated with the fat also increase in bound water content on aging. This shows that they are partially responsible for the increase in the bound water content of dairy products containing butterfat.

THE RELATION OF BOUND WATER CONTENT TO THE VISCOSITY OF SWEET CREAM

Cream was prepared according to the Hening and Dahlberg method (17) and its viscosity and bound water content compared with raw cream and ordinary pasteurized cream. The method used is as follows: Raw cream is pasteurized at 143° F. for 30 minutes and then cooled to 40° F. or lower. It is then warmed to 84° F. in seven minutes and cooled to 48° F. in 14 minutes. The cream is cooled to 40° F. in a refrigerator.

It was thought that since this method produces such a noticeable increase in viscosity, there may be a corresponding increase in bound water content. Therefore, a number of studies were made on fresh cream and cream after 24 hours of storage at 40° F. (Table 9).

The Hening and Dahlberg method of increasing the viscosity of sweet cream shows an increase in the bound water content over ordinary pasteurized sweet cream held at 40° F. for 24 hours, although less bound water is present than is present in aged raw cream.

Hening and Dahlberg found that the increased viscosity obtained by this

TABLE 9

The effect of temperature treatment on the bound water content and viscosity of sweet cream

Treatment	Hours aged at 40° F.	Per cent solids	Viscosity centipoises	Alcohol No.	Per cent bound water	Grams bound water per gram solids
1. Unheated	0	40.25	24.694	5.0	5.39	0.134
	24	40.25	29.796	5.2	6.26	0.156
2. Heated to 143° F. for 30 min.	0	41.40	22.653	5.2	3.94	0.095
	24	41.40	25.918	5.3	5.11	0.123
3. Special temperature treatment	0	41.49	20.000	5.2	4.95	0.119
	24	41.49	28.751	5.4	5.64	0.136

method of treating cream could not be associated with increased clumping of the fat globules. These results were substantiated by the writers. From the data obtained it is shown that the hydrophylic colloids become more hydrated by this temperature treatment, though this is not necessarily offered as an explanation for the viscosity change obtained.

THE RELATION OF BOUND WATER CONTENT TO VISCOSITY

In this work a study was made of the data presented to show, if possible, the relationship between viscosity and bound water content in dairy products. In viscosity studies we are usually dealing with lyophilic systems, since in general the lyophobic sols exhibit a viscosity which approaches very closely the viscosity of the pure dispersions medium, and which increases only slightly with increasing concentration of dispersed material. In dairy products we are dealing with a heterogeneous system. Nevertheless, changes in bound water content should produce changes in viscosity although the differences may not be well defined.

The viscosity studies in Tables 4, 6, 7, 8 and 9 show that the aging of liquid dairy products at low temperatures usually causes an increase in viscosity and bound water content. It appears in these tables that the greater the amount of solids present, the greater is the increase in viscosity on aging. In many of these instances the increases do not appear very great but when the initial viscosities are taken into consideration they are significant. Undoubtedly the increase in viscosity on aging is due to the increase in bound water content of the lyophilic colloids. These results agree with those of Evenson and Ferris (18) and Dahlberg and Hening (19) who show that aging increases the viscosity of milk and cream.

The pasteurization of milk and cream causes a decrease in the viscosity and the bound water content. The viscosity of milk and cream did not return to the original reading even after aging at low temperatures as can be seen in Tables 1, 2, 3, 4 and 9. Many workers, especially Dahlberg and Hening (19), Evenson and Ferris (18), and Babcock and Russell (20) have

demonstrated that heating of whole milk causes a diminution of the viscosity.

Table 8 shows that homogenization increased the viscosity of ice cream mixes and decreased the bound water content. The greater the pressure of homogenization the more pronounced was the increase in viscosity and decrease in bound water content. It will be noted in mix sample No. 4 of Table 8 that dual homogenization decreased the viscosity and increased the bound water content. Undoubtedly the increase in viscosity in single homogenization is due to the clumping of the fat globules, and to greater fat surface.

THE RELATION OF BOUND WATER TO PROTEIN STABILITY

The alcohol stability determination is probably the most accurate test used to measure the stability of the proteins in certain dairy products. A relatively high alcohol number is usually associated with greater heat and acid stability, and stability to homogenization and freezing.

Throughout this investigation, where feasible, the alcohol number was determined to note if any correlation between alcohol stability and bound water content was obtained. Some of the more positive results are recorded in Table 10.

TABLE 10

The relation of bound water content to protein stability in some dairy products

Sample	Hours aged at 40° F.	Per cent solids	Alcohol No.	Per cent bound water
1. Raw milk	24	11.92	8.1	3.75
2. Milk pasteurized at 143° F. for 30 min.	24	12.09	9.1	3.56
3. Milk pasteurized at 160° F. for 5 min.	24	11.94	9.3	3.06
4. Milk pasteurized at 180° F. momentarily	24	12.11	9.3	3.30
5. Raw cream	0	40.25	5.0	5.39
	24	40.25	5.2	6.26
6. Cream pasteurized at 143° F. for 30 min.	0	41.40	5.2	3.94
	24	41.40	5.3	5.11
7. Condensed skimmilk	0	26.27	5.0	8.09
	24	26.27	5.3	10.97
8. Superheated condensed skimmilk	0	26.43	5.7	8.99
	24	26.43	5.8	10.57

The aging of dairy products at low temperatures for 24 hours does not have any marked effect upon the alcohol stability, although the trend throughout this work (1, 2) does in some cases show a slight increase in alcohol stability with the increase in bound water content. In most cases the alcohol stability determination either showed that a slight increase or no change in stability resulted upon aging the sample.

That high heat treatment usually results in a decrease in bound water content and an increase in alcohol stability is shown in Tables 2, 3 and 10.

It was found by the writers in a previous investigation (2) that homogenization decreased the bound water content of milk plasma mixes containing butterfat and also decreased the alcohol stability. As the pressure is increased there is an increase in the degree of fat clumping and a decrease in the alcohol stability and bound water content. Dual homogenization decreased the fat clumping, increased the bound water content, and also increased the alcohol stability of the mix.

The results noted in Table 10 indicate that some dairy products, notably cream and condensed skimmilk, do increase in alcohol stability and bound water content on aging.

Previous results (2) also show that milk stabilizing salts slightly increased the alcohol stability and bound water content, while the milk destabilizing salts decreased the alcohol stability and the bound water content.

SUMMARY AND CONCLUSIONS

The bound water content of the milk colloids does not appear to contribute to the creaming ability of milk. High temperature treatment of the whole milk or skimmilk is detrimental to the creaming ability and bound water content of the milk while high temperature treatment of the cream portion does not affect creaming to any great extent.

The increase of the specific gravity of fresh milk and skimmilk on aging (Rechnagel's phenomenon) is thought to be partially due to the increase in the bound water content of the proteins and other hydrophilic substances present in milk.

Vacuum roller dry skimmilk loses some of its bound water with age. The greatest amount is lost during the first few weeks of storage. The dry skimmilk stored in open containers was affected more than the dry skimmilk stored in air-tight containers.

Superheating of condensed skimmilk had no appreciable effect upon the bound water content.

Short aging periods of concentrated milk plasma at relatively high temperatures resulted in only slightly more bound water than longer aging periods at low temperatures.

Invariably aging caused an increase in bound water content, regardless of the treatment given the sample.

The Dahlberg and Hening method of increasing the viscosity of cream by temperature treatment resulted in an increase in the bound water content of the cream.

Pasteurization of milk or cream lowered viscosity and bound water content.

Homogenization of mixes with one pressure increased viscosity and decreased the bound water content, while dual homogenization of the same product showed an increase in bound water content and viscosity.

The protein stability as measured by the alcohol number usually showed little change with changes in bound water content unless large changes were noted in the amount of bound water present. However, heating of milk to high temperatures decreased the bound water content but increased the stability toward alcohol, while superheating of condensed skimmilk resulted in increased stability with practically no change in bound water content.

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THE RELATION BETWEEN ACID DEFECTS AND HYDROGEN ION CONCENTRATION IN BRICK CHEESE

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Measurements of hydrogen ion concentration have proved to be a useful means of following acid development in American (1, 6, 7, 8) and Swiss cheese (2, 3, 4, 5) during manufacturing and the early part of curing. These measurements in American cheese are so closely related to the flavor and body characteristics of the ripened cheese that they can be used advantageously in the control of acid. Observations are reported in this discussion which seem to indicate that measurements of hydrogen ion concentration of Brick cheese during the first few days of curing may be a very useful guide for controlling subsequent manufacturing processes.

The successful making of Brick cheese with *Streptococcus lactis* starter requires the development of acidities which, if they are not carefully controlled, may cause defective cheese. The flavor, body and texture of Brick cheese are all directly influenced by the acidity development. Excessive amounts of acid delay ripening, cause undesirable acid or sour flavors, and crumbly, mealy bodied cheese. Low acidity, on the other hand, encourages the development of abnormal, gassy fermentations and causes excessively open texture and abnormal flavors in the cheese. Increases in the yield are usually attempted by reducing the acidity so that more moisture will be retained in the cheese. Such manipulations may produce very sweet or, what is more surprising, very acid cheese.

It is not always easy to detect abnormally acid or sweet cheese by sense of taste or body characteristics soon enough in the curing process to prevent repetition of the fault. Measurements of hydrogen ion concentration were, therefore, made during the first week of curing 72 lots of cheese and these values have been correlated with the criticisms of competent judges. The results are reported in this paper.

Acid measurements were made with the quinhydrone electrode, saturated calomel half-cell and a Leeds-Northrup portable potentiometer. Measurements are reported in pH units. Samples of cheese were taken by cutting each loaf in half across the long dimension and then removing a cross section slice. The whole slice, excluding the rind, was used for the analyses.

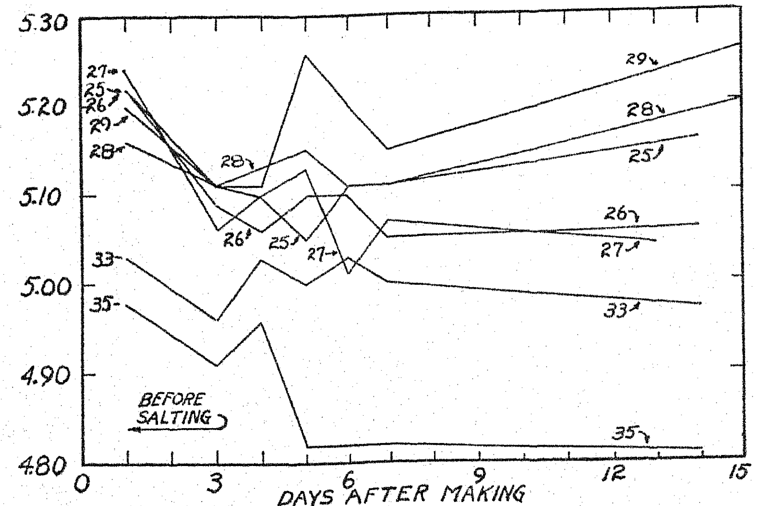
DAILY VARIATIONS IN ACIDITY

Daily variations in acidities of 7 typical lots of Brick cheese are shown in Figure 1. Acid measurements were made on these lots when they were taken

Received for publication April 10, 1938.

[1] Industrial Fellow on a grant from the Kraft-Phenix Cheese Corporation.

from the hoops just before salting, again on the third day just after salting, and daily, thereafter, until the 7th day after making. The last measurement was made at the time of paraffining on about the 14th day. All 7 lots varied somewhat in acid during this period, the maximum variation equaling 0.15 pH units. The pH on the third day after making approximated the minimum for most of the lots. Toward the end of the week the acidities generally approximated the values observed on the third day. During the second week the acid values of these seven lots became relatively divergent. Such variations must be expected because of sampling different loaves of cheese, changing salt concentrations, bacteriological activity and the limits of accuracy of the method of acid measurement.



CHANGES IN ACIDITY OF 7 LOTS OF BRICK CHEESE FROM SALTING TO PARAFFINING

FIG. 1

After the first week of curing there was in general, a slight increase in the average pH of all lots. This trend continued as the cheese ripened. Individual lots acted differently in rate of pH increase. Such variations explain why, during the later stages of ripening, individual lots of sweet and acid Brick cheese may actually have the same pH values. This has also been observed in ripening American cheese.

RELATION BETWEEN ACIDITY OF CHEESE AND ACID DEFECTS

Forty-eight lots of Brick cheese have been classified in Table 1 according to the "Acid Grade." The acid grade indicates the degree of acidity in flavor and body detected by the judges. Satisfactory cheese is called "sweet" and given an acid grade of zero. "Trace of acid," "acid," "very acid" and "sour" indicate increasing degrees of acidity and are given grades of 1, 2,

3 and 4, respectively. The average pH values calculated for the cheese in each acid grade tended to decrease with the exaggeration of the defect. Sweet cheese had an average pH of 5.09 three days after making while sour cheese had an average pH of 4.92. Comparison of average values on the third and seventh days shows no significant differences. Actually the averages of the pH of all the cheese in the four acid grades were identical on these two days.

TABLE 1

Average pH of Brick cheese in each acid grade

Acid grade	Number of lots	Average acidity	
		3 days after making	7 days after making
		pH	*pH*
Sweet	28	5.09	5.12
Trace of acid	4	5.03	5.02
Acid	8	4.95	4.95
Very acid	3	4.99	5.03
Sour	5	4.92	4.91

The relation between acid measurements on the third and seventh days after making and the acid grade is shown in Figure 2. Numerical values representing the average acid grade for corresponding pH classes have been averaged, then plotted and a smooth curve has been drawn to fit the data obtained on the third day. Data from the seventh day were too scattered in the high acid range to justify a smooth curve. This figure, as well as Table 1, indicates that pH measurements as a whole were directly related to the flavor and body characteristics of the cheese. As the pH decreased, the cheese became increasingly acid in the opinion of the judges. Third day measurements, however, seem to be more closely related to the acid grade than those

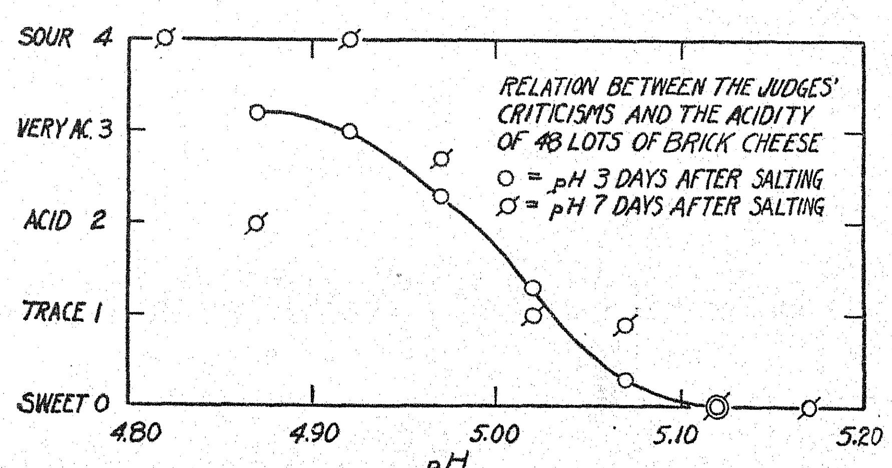


FIG. 2

obtained on the seventh day. Measurements on the fourth day after making approximate the significance of those on the third day.

Any degree of acid defect may be regarded as undesirable. All forty-eight lots of cheese were therefore divided into sweet and acid defective groups. The lots of cheese in each group were classified according to their acidity on the third day after making and the results are shown in Table 2.

TABLE 2

Relation between the judges' criticisms and the acidity of Brick cheese 3 days after making

Acidity of cheese 3 days after making	Total of sweet and acid lots	Sweet cheese	
pH	*Number*	*Number*	*Per cent*
5.10 to 5.19	14	14	100
5.00 to 5.09	21	13	62
4.90 to 4.99	9	1	11
4.80 to 4.89	4	0	0

When the pH of the cheese was 5.00 to 5.09 a slight majority of lots were sweet but there were almost as many acid defective cheese in this grade. Below pH 5.00 only one lot was called sweet. Table 3 illustrates the same arrangement of data obtained from measurements of pH on the seventh day. Here again pH values of 5.10 or more are associated only with sweet cheese, while below this value some cheese are sweet but more are acid defective. It seems safe to state that pH values of Brick cheese should never fall below 5.10 on the third day or seventh day after making if acid defective cheese is to be avoided.

TABLE 3

Relation between the judges' criticisms and the acidity of Brick cheese 7 days after making

Acidity of cheese 7 days after making	Total of sweet and acid lots	Sweet cheese	
pH	*Number*	*Number*	*Per cent*
5.20 to 5.29	3	3	100
5.10 to 5.19	17	17	100
5.00 to 5.09	16	8	50
4.90 to 4.99	7	0	0
4.80 to 4.89	5	0	0

Manufacturers or buyers may have difficulty in always measuring pH on the third day after making. Values of pH on other days as indicated in Figure 1 may vary widely from those made on the third day. However, even random measurements during the first seven days after making still have some value as indicated in Table 4. Here, pH measurements made on 72 lots of Brick cheese during the first week of curing have been classified in the same manner as the data in Tables 2 and 3. The highest or most favorable pH value observed for each lot during the first seven days after making was

selected as the basis of the acid classification in Table 4. Even when these values are used to predict the acid grade of the cheese the pH 5.10 standard still maintains its significance. The chances of making acid defective cheese are very slight when the pH during the first week of curing remains at 5.10 or more.

TABLE 4

Relation between pH and quality when cheese is classified by the highest pH values observed during the first week after making

Highest pH observed during first week	Total of sweet and acid lots	Sweet cheese	
pH	*Number*	*Number*	*Per cent*
5.20 to 5.29	4	4	100
5.10 to 5.19	27	26	93
5.00 to 5.09	21	7	35
4.90 to 4.99	15	1	6
4.80 to 4.89	5	0	0

Cheese buyers who receive Brick cheese after approximately two weeks of curing cannot apply so well the pH method of judging acidity. At two weeks of age the pH values of some lots of acid cheese may actually be well above the 5.10 standard of the first week of curing. This fact is illustrated in Table 5 which shows two acid lots of cheese with a pH of more than 5.20 and approximately two-thirds of all acid lots under observation above pH 5.00. Practically all pH values for sweet cheese fall in the same classes with about one-third in the pH 5.20 to 5.29 group. This over-lapping of the acidities of sweet and acid cheese at this time makes measurements of little value unless they happen to be extremely high or low. Actually, however, pH measurements are not necessary at this time, since by the fourteenth day after making, acid flavor and short body are easily detected by any competent judge.

TABLE 5

Relation between the judges' criticisms and the acidity of Brick cheese at paraffining

Acidity of cheese at paraffining*	Total of sweet and acid lots	Sweet cheese	
pH	*Number*	*Number*	*Per cent*
5.20 to 5.29	14	12	86
5.10 to 5.19	19	15	79
5.00 to 5.09	25	9	36
4.90 to 4.99	11	2	18
4.80 to 4.89	3	0	0

* Paraffining occurred 13 to 18 days after making.

CONCLUSIONS

The pH of Brick cheese three days after making is a useful index of the acid characteristics of the ripened cheese. The minimum pH should not be

less than 5.1 at this time. The fact that the observed limit of acidity approximates that desired in American cheese indicates the similarity of the two types of cheese and emphasizes the significance of pH in controlling the elastic properties and the flavor of fresh cheese. Undoubtedly characteristic acidity limits distinguish other varieties of cheese.

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DETECTING THE NEUTRALIZATION OF MILK WITH THE CRYOSCOPE

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In the examination of milk for the addition of neutralizers, it is frequently impossible to say definitely that a sample has been adulterated. This is probably due to the fact that the present tests which have been proposed are based on a characteristic or constituent of milk that is too variable.

Tillmans and Luckenback (11), for example, suggest a method (later modified by Sommer (9)), which is based on the difference between the buffer capacity of normal and neutralized milk of the same acidity.

Mojonnier (7) devised a method for the determination of lime in dairy products. If the amount of lime found in a suspected sample exceeds the normal amount, the sample may be considered to be neutralized.

The pH (6) may be determined either with indicators, such as brom thymol blue, or by the electrometric method; and neutralization may be deduced from an abnormally alkaline pH.

A method was proposed by Nottbohm (8) for determining the sodium–potassium ratio in the suspected milk. An abnormally greater proportion of sodium to potassium indicated neutralization.

Since the present methods are not generally accepted, it was thought that a method, to be acceptable, should be based upon some constant characteristic of milk such as the freezing point. A method such as this was published by Koenig and Kluge (5). Although they reported the results on only three neutralized samples of milk, the method appeared to be of value. They stated that if the corrected freezing point lies below −.554° C., neutralization is indicated. The corrected freezing point is obtained in the following manner: Subtract 7 from the observed Soxhlet-Henkel degrees acidity and multiply the result by .007. Subtract this figure from the observed freezing point.

In studying neutralized milk, the greatest difficulty involved is the wide variation of the original acidity of different samples of milk. Caulfield and Riddell (2) report variations from .098 to .295 per cent acidity of milk from cows in Kansas. Experience in this laboratory is in agreement with Caulfield and Riddell; a range of .09 to .245 per cent acidity was found in 4,000 samples of milk. Consequently, if an unknown sample of milk has an acidity of from .09 to .25 per cent it cannot be definitely regarded as sour, normal, or neutralized by the determination of acidity alone.

Received for publication March 26, 1938.

Hortvet (3), Keister (4), Bailey (1), and others have done a considerable amount of work on the freezing point and its relation to the souring of milk. There are also many reports regarding the effect of heat, garget, colostrum, skimming, age of cow, breed of cow, period of lactation, season of the year, etc., all of which show that these factors have no appreciable effect upon the freezing point of pure milk. There was yet to be shown, therefore, the normal variations that might be expected between the developed acidity of normal milk and its freezing point. It was also necessary to show the effect of various neutralizers on the freezing point.

EXPERIMENTAL

All of the work herein reported was done on samples of known purity from herds of two to twenty cows each. Each sample was examined for bacteria count, acidity, pH, and freezing point. It was then allowed to sour spontaneously and again examined for acidity, pH, and freezing point. The sour sample was then divided into two to eight parts depending upon the nature of the experiment and neutralized with NaOH, $NaHCO_3$, Na_2CO_3, and $MgCO_3$ in the dry form. These samples were in turn examined for acidity, pH, and freezing point. The relationship existing between pH and freezing point is not as definite as the one between acidity and freezing point. For this reason and for the sake of brevity, all the pH readings obtained are not reported. However, they were run on all samples as a check on the acidity.

Acidity was determined by pipetting 17.6 ml. of the sample into a white container, adding ½ ml. of 1 per cent phenolphthalein and titrating to a faint pink color with .1 N NaOH. The number of milliliters divided by 20 equals the per cent acidity calculated as lactic acid and was so recorded.

Bacteria counts were made on the fresh samples by the Breed direct method. In no case did the count exceed 300,000 and averaged 100,000 for all samples examined. The samples were therefore considered to be devoid of developed acidity.

Freezing points were determined with a Hortvet (3) cryoscope, the procedure given in Standard Methods of Milk Analysis (10) being followed exactly. A blower of the type used in electric insect spray guns was employed as a source of compressed air. An adjustable type vacuum windshield wiper, the arm of which was hooked to the stirrer, served as a means of mechanically agitating the milk during freezing.

The determinations of pH were made electrometrically with a quinhydrone electrode.

RESULTS

Twenty-eight samples of raw milk were allowed to sour spontaneously and freezing points determined at various acidities. These results are given in Table 1. If each sample is plotted, it can be shown that there is a

TABLE 1

Effect of souring on freezing point

Sample number	Acidity	Freezing point – °C.	Sample number	Acidity	Freezing point – °C.
2	.145	.540	13	.12	.548
	.18	.568		.195	.570
5554	.145	.557	224	.14	.557
	.235	.594		.175	.567
682	.22	.550	899	.155	.548
	.32	.582		.19	.558
3485	.11	.545	4018	.15	.547
	.13	.547		.22	.575
				.32	.609
4569	.15	.552		.36	.637
	.205	.562		.40	.645
	.24	.575		.50	.677
	.44	.632		.60	.716
	.56	.660			
	.61	.697	113	.135	.550
				.18	.562
21	.15	.548		.24	.588
	.20	.566		.39	.638
	.24	.600		.50	.697
	.47	.680			
	.59	.719	22	.15	.548
				.24	.600
131	.13	.550			
	.24	.588	5290	.155	.540
				.30	.590
2380	.14	.542			
	.30	.609	1854	.15	.558
				.21	.580
36	.135	.558			
	.23	.578	4019	.145	.541
	.35	.620		.24	.580
	.37	.622		.33	.611
	.53	.675		.45	.645
				.61	.698
4408	.155	.551			
	.215	.580	3900	.11	.548
	.295	.601		.225	.584
	.41	.631		.30	.609
	.53	.674		.455	.640
				.605	.697
1333	.15	.540	1310	.18	.553
	.23	.562		.215	.568
	.295	.592			
	.375	.632	371	.155	.533
	.52	.657		.295	.576
			6137	.165	.542
370	.165	.540		.215	.562
	.215	.560			
	.33	.599	5290	.15	.541
	.46	.632		.235	.572
	.57	.674			
			5289	.16	.540
5328	.16	.550		.24	.591
	.20	.590			

straight line relationship between developed acidity and freezing point. This relationship varies from sample to sample probably due to (a) differences in the original titratable acidity of the milk and (b) differences in the amount of lactose and any other fermentable substances present. The extremes found in all samples studied—including those of Keister's (4) and Bailey's (1) are shown in Figure 1.

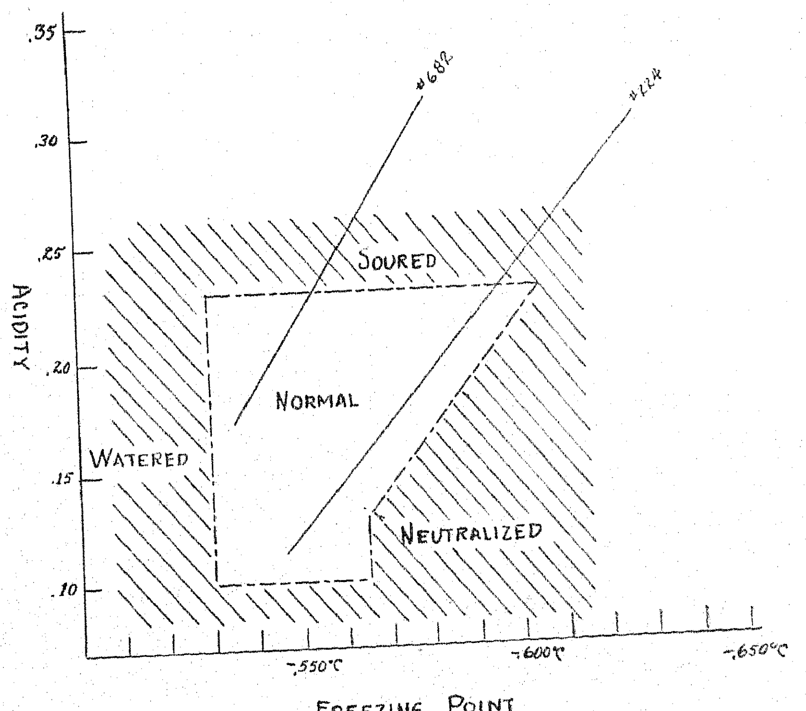

FIG. 1. Maximum (#224) and minimum (#682) freezing-point-acidity curves found in 40 samples of normal milk including those of Bailey's and Keister's. The shaded area represents abnormal milk.

It was recognized that only a small number of samples were tested and those from just one section of the country. A certain leniency, therefore, was allowed when determining whether or not a sample was neutralized. The shaded portion of Figure 1 was considered abnormal for pure milk and any point in this area was judged watered, neutralized, or soured according to its location.

In Table 2 is recorded the effect of the addition of four kinds of neutralizers on the freezing point and acidity. In columns eight and nine an attempt was made to characterize the sample as if it had been of unknown origin. This was based on the acidity and freezing point of the sample

according to Figure 1. If the location of the plotted point was in the shaded area, the sample was considered neutralized; if on the dotted line, doubtful; and if in the clear area, normal. As will be observed from the table, of the 45 samples that were neutralized from .015 to .29 per cent

TABLE 2

Effect of neutralization on freezing point

Sample number	Normal		Soured		Neutralized		Max. fr. pt. allowable for acidity, if normal. − °C.	Characterization of sample, if unknown
	Acid %	Fr. pt. − °C.	Acid %	Fr. pt. − °C.	Acid %	Fr. pt. − °C.		
				(neutralized with $NaHCO_3$)				
2	.14	−.540	.205	−.568	.12	−.608	−.565	neutralized
13	.12	.548	.195	.570	.125	.608	.565	"
554	.145	.557	.235	.594	.15	.634	.575	"
224	.14	.557	.175	.567	.145	.572	.570	doubtful
682	.22	.550	.32	.582	.22	.607	.600	"
899	.155	.548	.19	.558	.15	.581	.575	neutralized
3485	.11	.545	.13	.547	.11	.560	.565	normal
22	.15	.548	.24	.600	.215	.741	.597	neutralized
131	.13	.550	.24	.588	.12	1.450	.565	"
1310*	.18	.553	.215	.568	.14	.652	.570	"
370*	.165	.540	.215	.560	.145	.800	.575	"
370	.165	.540	.215	.560	.20	.864	.595	"
371*	.155	.533	.295	.576	.115	.995	.565	"
6137*	.165	.542	.215	.562	.15	.646	.575	"
5290*	.15	.541	.235	.572	.16	.650	.577	"
5328*	.16	.550	.255	.585	.19	.651	.590	"
				(neutralized with Na_2CO_3)				
3900*	.11	.548	.225	.584	.16	.628	.577	"
3900	.11	.548	.225	.584	.12	.615	.565	"
371*	.155	.533	.295	.576	.06	.672	.565	"
6137*	.165	.542	.215	.562	.105	.600	.565	"
5290*	.15	.541	.235	.572	.12	.621	.565	"
5289	.16	.540	.24	.591	.14	.630	.570	"
5328*	.16	.550	.255	.585	.185	.604	.585	"
				(neutralized with NaOH)				
5290	.155	.540	.30	.590	.01	.640	.565	"
2388	.14	.542	.30	.609	.08	.628	.565	"
2	.15	.548	.24	.600	.12	.600	.565	"
1854	.15	.558	.21	.580	.18	.596	.585	"
13	.14	.550	.21	.561	.15	.582	.575	doubtful
36*	.135	.558	.23	.578	.12	.580	.565	neutralized
4019	.145	.541	.24	.580	.125	.592	.565	"
4019*	.145	.541	.24	.580	.105	.589	.565	"
4408	.155	.551	.215	.580	.16	.582	.577	doubtful
4408*	.155	.551	.215	.580	.155	.580	.575	"
1310*	.18	.553	.215	.568	.155	.570	.575	normal
371*	.155	.533	.295	.576	.09	.591	.565	neutralized
6137*	.165	.542	.215	.562	.02	.580	.565	"
5290*	.15	.541	.235	.572	.04	.584	.565	"
5328*	.16	.550	.255	.585	.20	.590	.600	normal

TABLE 2.—(*Continued*)

Sample number	Normal		Soured		Neutralized		Max. fr. pt. allowable for acidity, if normal. − °C.	Characterization of sample, if unknown
	Acid %	Fr. pt. − °C.	Acid %	Fr. pt. − °C.	Acid %	Fr. pt. − °C.		
				(neutralized with $MgCO_3$)				
36	.135	.558	.23	.578	.12	.578	.565	neutralized
1333	.15	.540	.23	.562	.20	.565	.595	normal
1310*	.18	.553	.215	.568	.17	.595	.582	neutralized
371	.155	.533	.295	.576	.04	.580	.565	"
6137*	.165	.542	.215	.562	.14	.562	.570	normal
5290*	.15	.541	.235	.572	.155	.588	.575	neutralized
5328*	.16	.550	.255	.585	.175	.586	.582	doubtful

* Neutralized portions heated to 160° F. for 20 seconds.

acidity, 5 would have been considered normal, 4 doubtful, and 36 neutralized.

Since it was necessary to heat the neutralized samples in order to obtain the correct acidity and also to assist the neutralization reaction, a study was made of the effect of heating on neutralized samples of milk. The samples were heated to 160° F. for 20 seconds and cooled immediately. Some of these results are given in Table 3. It was found that heat has a

TABLE 3

Effect of heat on freezing point of normal, soured, and neutralized samples

Sample		Normal	Normal heated	Soured	Soured heated	Neutralized	Neut. heated
4019 (NaOH)	acid	.145	.13	.24	.235	.125	.105
	pH	6.60	6.66	6.06	6.15	6.61	6.81
	fr. pt.	.541	.544	.580	.579	.592	.589
4408 (NaOH)	acid	.155	.15	.215	.215	.16	.155
	pH	6.55	6.57	6.20	6.17	6.63	6.58
	fr. pt.	.551	.550	.580	.579	.582	.580
3900 (Na_2CO_3)	acid	.11	.105	.225	.205	.16	.12
	pH	6.87	6.87	6.03	6.15	6.61	6.83
	fr. pt.	.548	.549	.584	.579	.628	.615
1333 ($MgCO_3$)	acid	.15	.14	.23	.21	.20	.14
	pH	6.69	6.72	6.21	6.35	6.46	6.72
	fr. pt.	.540	.538	.562	.559	.565	.560
370 ($NaHCO_3$)	acid	.165	.15	.215	.21	.20	.145
	pH	6.61	6.60	6.40	6.37	7.09	7.49
	fr. pt.	.540	.538	.560	.560	.864	.800

variable effect upon the freezing point of a neutralized sample depending upon the kind of neutralizer used. In all cases, the freezing point of the heated neutralized sample was higher than the same sample which was not heated and lower than the soured sample that was not neutralized. This

indicates that once a sample of milk has been neutralized, heating will not affect the accuracy of the cryoscopic method of detection of neutralization.

The effect of different neutralizers on the freezing point of the same sample was next considered. In this study, an attempt was made to neutralize the samples to the same acidity or pH. This was found difficult particularly since all neutralizers were added in the dry form to relatively small amounts of milk (200 ml.). Furthermore, the true acidity could not be determined until after the sample had been heated. It was thought inadvisable to heat the sample more than once since prolonged heating would have a concentrating effect and therefore alter the freezing point. It was found that NaOH and $MgCO_3$ depressed the freezing point the least, Na_2CO_3 next, and $NaHCO_3$ the most. Ordinary baking soda ($NaHCO_3$) is probably most frequently used as a neutralizer on the farm, which, fortunately, has been shown to be the easiest to detect. These results are given in Table 4.

TABLE 4

Effect of different neutralizers on same sample

(Neutralized samples heated)

Sample		Normal	Soured	Neut. NaOH	Neut. $NaHCO_3$	Neut. Na_2CO_3	Neut. $MgCO_3$
36	acid	.135	.235	.12	....	....	.12
	pH	6.61	6.14	6.76	....	....	6.85
	fr. pt.	.558	.578	.580	....	....	.579
1310	acid	.18	.215	.155	.14	.14	.17
	pH	6.51	6.29	6.60	7.02	6.70	7.23
	fr. pt.	.553	.568	.570	.652	.600	.595
371	acid	.155	.295	.09	.115	.06	.04
	pH	6.55	5.89	7.01	7.61	7.41	7.60
	fr. pt.	.533	.576	.591	.995	.672	.580
6137	acid	.165	.215	.02	.15	.105	.14
	pH	6.58	6.27	8.25	6.82	7.03	6.73
	fr. pt.	.542	.562	.580	.646	.600	.562
5290	acid	.15	.235	.04	.16	.12	.155
	pH	6.61	6.15	7.80	6.82	6.97	6.63
	fr. pt.	.541	.572	.584	.650	.621	.588
5328	acid	.16	.255	.20	.19	.185	.175
	pH	6.59	6.14	6.56	6.76	6.55	6.59
	fr. pt.	.550	.585	.590	.651	.604	.586

The next question of interest was the effect of further souring on the freezing point of a neutralized sample. As will be seen from a study of Table 5, the straight line relationship of freezing point and acidity is still maintained in the range studied (up to .60 per cent). However, the depression of the freezing point due to neutralization persists. These results are shown graphically in Figure 2, and from them, it may be concluded that

TABLE 5

Effect of further souring after neutralization on freezing point

Sample		Normal	Soured	Neut.	Neut. and soured	Neut. and soured
5328 (NaOH)	acid	.16	.255	.20	.26	.41
	pH	6.59	6.14	6.56	6.20	5.58
	fr. pt.	.550	.585	.590	.612	.671
5328 ($NaHCO_3$)	acid	.16	.255	.19	.235	.38
	pH	6.59	6.14	6.76	6.48	5.67
	fr. pt.	.550	.585	.651	.665	.725
5328 (Na_2CO_3)	acid	.16	.255	.185	.28	.36
	pH	6.59	6.14	6.55	6.03	5.78
	fr. pt.	.550	.585	.604	.640	.670
5328 ($MgCO_3$)	acid	.16	.255	.175	.30	.375
	pH	6.59	6.14	6.59	5.94	5.87
	fr. pt.	.550	.585	.586	.637	.670
5289 (Na_2CO_3)	acid	.16	.24	.14	.23	....
	pH	6.58	6.13	6.93	6.37	....
	fr. pt.	.540	.591	.630	.660	....
22 ($NaHCO_3$)	acid	.15	.24	.215	.30	.46
	pH	6.62	6.01	6.79	6.31	5.83
	fr. pt.	.548	.600	.741	.836	.897
2388 (NaOH)	acid	.14	.30	.08	.33	.42
	pH	6.58	5.97	6.90	5.60	5.42
	fr. pt.	.542	.609	.628	.725	.771
2 (NaOH)	acid	.15	.24	.12	.21	.34
	pH	6.62	6.01	6.58	6.08	5.56
	fr. pt.	.548	.600	.600	.670	.721

further souring does not affect the accuracy of the cryoscopic method for the detection of neutralization.

As a check on the way an inexperienced worker would be able to detect neutralizer, an assistant was given 14 samples of milk of unknown origin. To some of these samples $NaHCO_3$ had been added in amounts varying from a tablespoon (8 gm.) to ½ cup (160 gm.) per 10 gallons of milk. He was then asked to judge the milk by acidity and freezing point alone without knowing if the samples had been neutralized or not. His results given in Table 6, indicate that he failed to detect neutralizer in No. 6 (possibly because the original sample may have been watered) and considered the sample containing a tablespoon of baking soda per 10 gallons of milk as doubtful. These results indicate that the test requires no special knowledge other than that of the maximum freezing points allowable for pure milk.

DISCUSSION

It is recognized that only a few samples of milk have been studied in determining the efficiency of this test. It was felt, however, that the num-

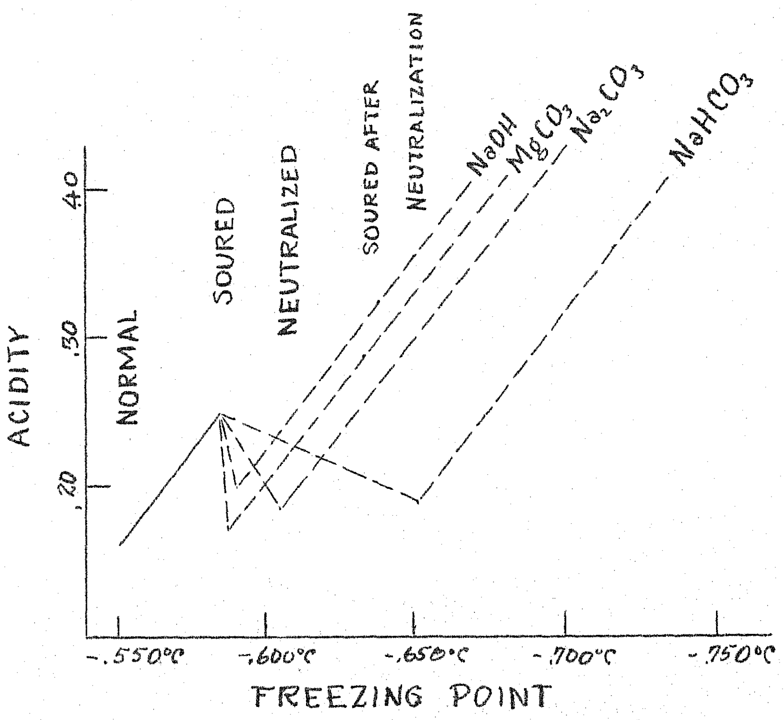

Fig. 2. Effect of further souring after neutralization on the freezing point.

TABLE 6

Results obtained on "prepared unknowns" as analyzed by an inexperienced worker

Sample number	Original sample		Results		
	Acid	Amount neutralizer added to 10 gal. milk	Acid	Fr. pt. −°C.	Remarks
1	.15	none	.155	.482	watered
2	.15	"	.15	.559	normal
3	.18	"	.27	.521	sour—watered
4	.18	"	.455	.628	" —normal
5	.25	80 grams	.23	.650	neutralized
6	.28	"	.25	.540	sour—normal (possibly watered)
7	.20	"	.165	.645	neutralized
8	.265	8 grams	.26	.622	sour—normal (possibly neutralized)
9	.30	160 grams	.245	.754	neutralized
10	.22	40 grams	.19	.643	"
11	.21	"	.20	.624	"
12	.195	"	.18	.609	"
13	.19	80 grams	.165	.611	"
14	.24	"	.235	.647	"

ber was sufficient to warrant its use in this particular section of the country, and it is hoped that work can be done elsewhere which will prove or disprove the value of this test. It has been used in this plant for several months and in the few neutralized samples found by this test, the producer admitted using baking soda. It may be said that this test has definitely increased the efficiency of our field work among the producers.

It is further hoped, that should this test prove satisfactory for milk, it can also be applied to cream. Some preliminary work done here indicated that once a maximum allowable freezing point-acidity curve has been established for cream of a certain fat percentage, the addition of small amounts of neutralizer can be detected.

CONCLUSIONS

1. There is a direct relationship between developed acidity and freezing point which varies only slightly from one sample to another.
2. Neutralizers such as NaOH or $MgCO_3$ do not lower the freezing point appreciably when used in necessary quantities.
3. Neutralizers such as Na_2CO_3 or $NaHCO_3$ lower the freezing point appreciably when used in necessary quantities.
4. Heating a neutralized sample tends to raise the freezing point slightly, but not enough to interfere with the accuracy of the test.
5. Neutralization of as little as .015 per cent can be detected depending upon the normal acidity of the neutralized sample and the kind of neutralizer employed.
6. Samples of milk with a low natural acidity (.10–.13 per cent) can be soured and neutralized as much as .075 per cent with NaOH without detection by this test.
7. After a sample has been neutralized, further souring will not affect the accuracy of the test.
8. The evidence available indicates that neutralization of milk can be detected by comparing the freezing point of the sample with the maximum allowable freezing point for a sample of that acidity.

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AN IMPROVED AND MODIFIED EVENSON COLOR TEST FOR "REMADE MILK"

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Due to complaints by various health officials regarding mislabelling of remade milk an investigation was made of the methods for detection of remade milk in fluid milk.

Since the principle upon which Evenson based his studies of remade milk (1, 2, 3, 4) seemed the most promising of all the others listed in the literature (5, 6, 7, 8) it was studied first. Evenson's method had the added advantage of having been published and used in several similar instances. Several other methods based on different principles were tried but as the following modification of the Evenson method gave such promising results the others were discontinued.

Pipette 45 to 50 cc. of liquid milk into a centrifuge tube and precipitate the protein by the use of 5 per cent acetic acid. Centrifugalize and decant the supernatant liquid, wash the protein with distilled water, using a mechanical stirrer to break up the lumps. Again centrifugalize and decant. Extract fat from the protein by washing with 50 cc. portions each of acetone, ether, and acetone in the order named, using the mechanical stirrer to secure efficient disintegration of the particles of protein. Then continue the washing with distilled water, using the mechanical stirrer in every case until two successive washings give negative "Molisch Tests" for carbohydrates.

After two consecutive washings which show no presence of carbohydrates with the "Molisch Test" add approximately 15 cc. of a NaOH solution (225 gms. NaOH made up to 500 cc.) to the protein precipitate in the tube and mix with a stirring rod until all of the protein has been broken up and wetted with the NaOH. After two hours judge the tubes for their color against a known sample of liquid milk which has been carried through the above procedure. The samples containing the remade milk will show a distinctly yellow color while the other will not.

The judging of the colors of the protein should be made in daylight and not under electric lights.

EXPERIMENTAL

Evenson in his article states that the method as he reported it would detect the addition of 10 per cent of remade milk in the liquid milk, but it

Received for publication May 3, 1938.

was believed possible to make this test more sensitive if a more thorough washing of the precipitated protein could be perfected.

At the beginning of the experimental work the protein was precipitated out of 25 cc. of liquid milk in a 50 cc. centrifuge tube with a 5 per cent solution of acetic acid. The whey was then removed by centrifugalization and on each addition of wash water to the protein in the tube the protein was broken up by a stirring rod and centrifuged off. This method of washing was very effective and gave results more sensitive than Evenson's method of washing. However, it required some twenty to twenty-five washings in order to remove the last traces of lactose. The number of washings required so much time that some further modification was sought. This led to the use of a mechanical stirrer which could be used as a means of breaking up the curd. This materially assisted in washing the protein free of any uncombined lactose, for it breaks the particles up to a degree of fineness which assures complete removal. It was found that with the mechanical stirrer it was necessary to increase the size of sample used from 25 cc. to 50 cc., since more protein is lost during the washing.

TABLE 1

Liquid milk number	Per cent remade milk added	Color	Remarks
1	0	–	
	5	+	
	10	++	
2	0	–	
	5	+	
	10	++	
3	0	–	
	5	+	
	10	++	
4	0	–	
	5	+	
	10	++	Did not show color with 5% but 10% showed color equal to 5% in other samples.
5	0	–	
	5	–	
	10	+	
6	0	–	
	5	+	
	10	++	
7	0	–	
	5	+	
	10	++	
8	0	–	
	5	+	
	10	++	
9	0	–	
	5	+(?)	(Very slight yellow)
	10	+	
10	0	–	
	5	+	
	10	++	

– No yellow color.
+ Distinct yellow.
++ Very decided yellow color.

The mechanical mixer used in this laboratory was a Bodine laboratory motor with a rheostat. The motor was equipped with a stirrer made from a glass rod with a corkscrew twist on the end to give a mixing effect. This was so arranged on a ring stand that the 50 cc. conical centrifuge tube could be clamped in place during the mixing. If a 100 cc. tube with a flat bottom is used an ordinary malted milk mixer can be conveniently employed.

It was also found during the experimental work that by using a more concentrated NaOH solution (225 gms. NaOH made up to 500 cc.) instead of the 5 per cent solution, along with the mechanical mixing, that a 5 per cent addition of remade milk could be detected without any question. The depth of color, however, depends a great deal upon the degree of heat used in the processing of the powdered milk.

The samples of milk used in this work were pasteurized milk picked up in the Chicago area and were carried through the above procedure, using 5 per cent and 10 per cent additions of remade milk from various types of spray process dry milk. The results on a few of these samples are listed in Table 1.

It will be noted that in two of the samples listed above the five per cent addition did not show up as clearly as in the majority of cases. This undoubtedly is due to the degree of heat used in the processing of the powdered milk and the extent of reaction between the lactose and the protein. However, in all of the samples which were studied there was not a single sample of liquid milk which gave a positive test unless remade milk had been added.

A large number of raw milk samples picked up in another large city were run through the above test with equally good results.

DISCUSSION

Evenson stated that his method would detect the addition of 10 per cent of remade milk in the liquid milk. It was found, however, that by the previously outlined procedure of washing the protein and using the more concentrated NaOH solution, that a 5 per cent addition of remade milk could be detected without any question. The depth of color, however, depends a great deal upon the degree of heat used in the processing of the powdered milk.

The use of the mechanical mixer very materially assists in washing the protein free of any uncombined lactose. Its use is essential for breaking up the particles of protein to the degree of fineness which assures a complete removal of the lactose. Use of the "Molisch Test" for carbohydrates has been recommended to indicate when the precipitate is adequately washed. The Molisch Test may be eliminated after the operator has gained experience and knowledge enough to know the effectiveness of his washing. It was found in this laboratory following our system of washing that ten washings after the fat extraction were sufficient.

During the work on this method it was observed that old fluid milks showed a grayish brown coloration with the NaOH solution but this was distinctly different from the yellow coloration of the remade milk. Even though there is a distinct difference, the grayish brown color does interfere with distinguishing the presence of the lower percentages of remade milks. The color comparisons must also be made in daylight and not under electric lights.

The development of the yellow color usually begins to appear in a few minutes after the mixing with the NaOH and reaches a maximum in 1½ and 2 hours. It was found that the contrast is more striking at the two hour period than later when an off-color begins to develop in the curd. This off-color interferes with the readings. However, the contrast is still apparent at the end of 24 hours.

SUMMARY

Modifications have been made in Evenson's color test for "Remade Milk" which facilitates the detection of 5 per cent of remade milk in fluid milk.

The modifications made in the Evenson test are an improved method of washing the protein and the use of a stronger solution of sodium hydroxide which gives a more striking contrast between remade milks and natural milks.

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RELATION BETWEEN RATE OF GROWTH AND MILK AND FAT PRODUCTION

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The efforts of research workers, breeders, and dairy farmers have been aimed for many years at ways and means of predicting production in dairy females before they were in milk. If some means could be devised to make such predictions at a period before the animals calved, a considerable saving would result and the breeding of dairy cattle would be facilitated. Prentice (1) has presented studies of the food consumption of calves which show correlation with their production at a later time. Turner (2) has intimated from his studies that the functioning of the pituitary might be closely related to milk production. It seemed, therefore, that a study of the rate of growth of young animals as correlated with the milk and fat production might yield results of interest. From the growth records of the University of Nebraska Holstein herd, 76 females were selected for this study. These animals were bred, reared, and tested for production in the herd under conditions that were as near comparable as possible. Furthermore, the animals were all closely related, since all were descended from families that have been closely related for about 30 years.

In making this study, three indices of growth were used, namely, gain in weight, increase in height at withers, and increase in chest girth. The birth measurements were compared with those at two years, and the percentage increase in the various measurements used as the rate of growth. Weights were determined by monthly weighings taken from three successive days and the average used. Measurements of height at withers were taken monthly with a calibrated measuring rod with a right-angle cross arm. The heights were measured in centimeters at the second dorsal vertebra when the animal was standing squarely on its four legs. The chest girth was taken in centimeters with a tape line around the chest, at the second dorsal vertebra at the top and just back of the elbows.

Table 1 presents the weights and measurements at birth and at two years, with the increase and percentage of increase for all Holsteins (3) compared with the average of the 76 females used in this study. It will be noted that there is a very close agreement between the standard as represented by all Holsteins in the table and the animals used in this study.

In order to study the possible relationship of gain in weight, increase in

Received for publication April 17, 1938.
Published with the approval of the Director as Paper No. 209, Journal Series, Nebraska Agricultural Experiment Station.

TABLE 1

Measurements of Holstein females at birth and two years with percentage increases

Type of measurement	Birth measurements	Two years measurements	Increase in measurements	Increase in per cent
Average of all Holsteins* Weight, lbs.	91	1108	1017	1117.6
Average 76 Females Weight, lbs.	87	1149	1022	1220.6
Average of all Holsteins* Chest girth, cm.	76.2	188.0	111.8	146.6
Average 76 Females Chest girth, cm.	77.9	190.2	112.1	144.1
Average of all Holsteins* Height at withers, cm.	73.7	133.4	59.7	81.0
Average 76 Females Height at withers, cm.	74.3	133.5	59.2	79.7

* Reference 3.

height, and increase in chest girth, three factors which are used to measure growth, a study was made of each factor as it might be related to subsequent milk and butterfat production, both for the first lactation and for the lifetime average of lactations. Thus, in Table 2 the 76 Holstein females were arranged in classes in accordance with their percentage of gain in weight at two years over the birth weight. The class interval range was 50 per cent and the classes varied from 900–949.9 per cent to 1750–1799.9 per cent with a mean of 1220.6 per cent gain. When the various individual animals were assigned to the group into which each belonged because of percentage gain in weight, the average birth weight, the average weight at two years, the average milk and fat production for one year for the first lactation and for the lifetime average of lactations was determined for each class together with the range in production. To make all production records comparable they were corrected to maturity, 365 days, for three-time milking. Thus the range in milk production was from 11,996 to 26,670 pounds of milk, and in fat production from 476 to 878 pounds of fat for the first lactation, with a simple average of 18,283 pounds of milk and 666 pounds of fat. For the lifetime average of lactations the range was from 12,117 to 26,670 pounds of milk and from 476 to 873 pounds of fat with a simple average of 18,040 pounds of milk and 651 pounds of fat. No statistical computations were made, but an inspection of Table 2 will indicate quite definitely that there is no marked correlation between the percentage gain in weight during the first two years and the production of milk and fat.

Table 3 presents a like comparison based upon increase in height as measured in height at withers in centimeters. The average height at withers at birth was 74.3 cm. and at two years of age 133.5 cm., a percentage increase of 79.7. The individual females were grouped according to gain in height, with class intervals of two per cent. Thus, the lowest class interval was

TABLE 2

Relationship of percentage of gain in weight two years over birth, with milk and butterfat production for first lactation and lifetime average

Weight			Animals	Production							
				First lactation				Lifetime average per lactation			
				Milk		Fat		Milk		Fat	
Birth	Two years	Gain at two years over birth		Range	Average	Range	Average	Range	Average	Range	Average
lbs.	*lbs.*	*per cent*	*No.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
96	985	900– 949.9	1		15,075		583		15,075		583
105.5	1121.5	950– 999.9	2		18,018	668–691	679	15,744–17,742	16,743	615–618	616
95.0	1073.0	1000–1049.9	5	15,124–18,277	13,376	590–680	637	15,124–17,315	16,213	569–624	594
93.8	1100.6	1050–1099.9	9	16,602–26,670	19,782	656–862	707	15,419–26,670	19,153	576–862	680
90.5	1112.6	1100–1149.9	8	11,996–22,080	18,116	476–806	651	13,088–22,080	18,276	494–775	649
87.4	1108.6	1150–1199.9	5	14,903–19,869	18,125	605–748	664	13,220–19,869	17,732	528–748	658
88.4	1174.1	1200–1249.9	13	12,829–23,262	17,602	501–816	661	12,117–21,123	17,454	488–752	639
86.8	1197.3	1250–1299.9	8	16,655–21,135	18,901	595–842	680	16,308–20,517	18,265	596–746	661
81.9	1163.5	1300–1349.9	8	13,844–23,675	17,554	476–878	650	13,995–20,468	17,422	476–762	633
80.2	1167.6	1350–1399.9	8	14,686–25,388	18,131	508–873	659	14,753–25,388	17,658	508–873	643
80.0	1218.5	1400–1449.9	4	15,268–23,276	19,306	562–739	653	15,310–23,276	19,979	535–741	673
71.0	1123.0	1450–1499.9	1		15,019		512		15,596		528
85.0	1400.0	1500–1549.9	1		20,413		720		21,770		764
		1550–1599.9	0								
		1600–1649.9	0								
		1650–1699.9	0								
65.0	1193.5	1700–1749.9	2	16,630–21,277	18,953		713	19,013–23,222	21,142	702–803	752
60.0	1120.0	1750–1799.9	1		21,775		815		20,979		752
Averages, All Animals											
87	1149	1220.6			18,283		666		18,040		651

TABLE 3

Relationship of percentage gain in height at withers two years over birth, with milk and butterfat production for first lactation and lifetime average

Height at withers			Animals	Production							
				First lactation				Lifetime average per lactation			
				Milk		Fat		Milk		Fat	
Birth	Two years	Gain at two years over birth		Range	Average	Range	Average	Range	Average	Range	Average
cm.	*cm.*	*per cent*	*No.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
74.5	128.0	70– 71.9	1		20,517		682		20,517		682
76.2	131.8	72– 73.9	4	16,692–20,696	18,692	607–667	644	15,614–20,696	18,505	569–678	633
75.2	131.0	74– 75.9	4	17,307–22,080	19,695	668–756	698	16,775–22,080	19,379	618–756	671
74.9	132.4	76– 77.9	18	11,996–21,247	17,215	476–734	637	13,088–21,770	17,305	508–746	634
75.2	134.5	78– 79.9	14	12,829–26,670	17,798	476–878	662	12,117–26,670	16,919	476–734	631
74.2	134.6	80– 81.9	14	14,546–25,388	19,436	584–873	715	14,546–25,388	19,398	584–873	710
72.4	132.4	82– 83.9	5	17,228–21,966	19,429	645–806	707	16,148–20,399	18,071	593–775	664
72.0	133.5	84– 85.9	6	14,686–23,262	17,494	512–816	616	15,310–18,926	16,620	528–684	591
71.0	133.2	86– 87.9	2	17,114–18,323	17,718	586–713	649	18,284–20,788	19,536	613–738	675
72.1	136.1	88– 89.9	4	14,356–19,869	17,979	551–728	639	13,995–21,123	18,692	526–728	642
72.0	137.0	90– 91.9	1		19,232		653		19,232		653
68.0	131.0	92– 93.9	1		21,775		815		20,979		752
70.0	136.0	94– 95.9	1		16,943		608		15,899		549
		96– 97.9	0								
		98– 99.9	0								
68.0	136.0	100–101.9	1		16,630		684		19,013		702
Averages, All Animals											
74.3	133.5	79.7			18,283		666		18,040		651

TABLE 4

Relationship of percentage gain in chest girth two years over birth, with milk and butterfat production for first lactation and lifetime average

Chest girth			Animals	Production							
				First lactation				Lifetime average per lactation			
				Milk		Fat		Milk		Fat	
Ave. at birth	Ave. at 2 yrs. of age	Gain at two years over birth		Range	Average	Range	Average	Range	Average	Range	Average
cm.	*cm.*	*per cent*	*No.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
84.5	187.3	120–123.9	3	17,315–21,247	19,477	591–748	669	17,315–21,247	19,477	591–748	669
80.0	181.5	124–127.9	2	18,236–20,517	[illegible]9,[illegible]76	680–682	681	16,783–20,517	18,650	624–682	653
82.0	188.6	128–131.9	9	13,944–26,670	19,475	554–873	693	15,124–26,670	19,595	575–873	684
82.3	192.6	132–135.9	3	18,277–23,276	20,749	656–739	687	15,614–20,696	19,862	569–739	654
81.4	194.0	136–139.9	10	12,829–22,080	17,686	501–756	649	12,117–22,080	17,466	488–756	636
77.6	188.0	140–143.9	6	16,602–18,567	17,581	637–693	659	16,148–21,123	18,615	593–746	675
77.8	191.8	144–147.9	15	11,996–2[illegible],675	18,[illegible]17	476–878	684	13,088–21,770	17,823	494–764	655
75.9	189.0	148–151.9	11	13,844–21,837	17,612	476–806	653	13,844–23,222	17,428	476–803	643
76.0	192.6	152–155.9	5	14,903–23,262	18,687	605–816	708	13,220–20,788	18,071	528–738	676
72.8	187.6	156–159.9	5	13,663–19,726	16,852	512–684	613	14,640–19,766	16,359	559–709	604
75.0	198.0	160–163.9	1		17,410		606		17,410		606
72.0	191.0	164–167.9	1		14,753		508		14,753		508
69.5	186.5	168–171.9	2	16,630–21,966	19,298	684–718	701	19,013–19,073	19,043	615–702	658
69.0	189.0	172–175.9	3	14,356–21,775	17,989	551–815	674	13,995–20,979	17,194	526–752	637
Averages, All Animals											
77.9	190.2	144.1			18,283		666		18,040		651

70–71.9 per cent and the highest 100–101.9 per cent. The lowest average of any class interval group had a height at birth of 68.0 cm., the highest average of a class interval group a height of 76.2 cm. At two years of age, the lowest average of any group was 128.0 cm. and the highest was 137.0 cm. The milk and fat production ranges and averages were much the same as in Table 2. An inspection of this table reveals no apparent correlation between rate of increase or growth in height, as measured in height of withers from birth to two years, and the production of milk and fat.

In Table 4 the increase in girth between birth and two years as measured in chest girth is presented in relation to production. The average chest girth at birth was 77.9 cm. and at two years it was 190.2 cm., an increase of 144.1 per cent. The individual females were grouped according to percentage increase in chest girth in four per cent class intervals. The classes ranged from 120.0–123.9 per cent to 172.0–175.9 per cent. Chest girth at birth varied in class interval averages from 69.0 cm. to 84.5 cm., while at two years the lowest class interval average was 181.5 cm. and the highest 198.0 cm. Here, again, the production showed much the same range and average, and an inspection of Table 4 will very definitely indicate the lack of correlation between increase in chest girth and production.

SUMMARY AND CONCLUSIONS

An attempt was made to correlate rapidity of growth as indicated by gain in weight, by increase in height at withers, and by increase in chest girth from birth to two years, with milk and fat production for the first lactation and for the lifetime average of lactations. Seventy-six Holstein females in the University of Nebraska dairy herd were used. While the animals were apparently normal as compared with standards established in that herd, no apparent correlation was observable for any of the three measurements.

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A MANGER FOR EXPERIMENTAL FEEDING

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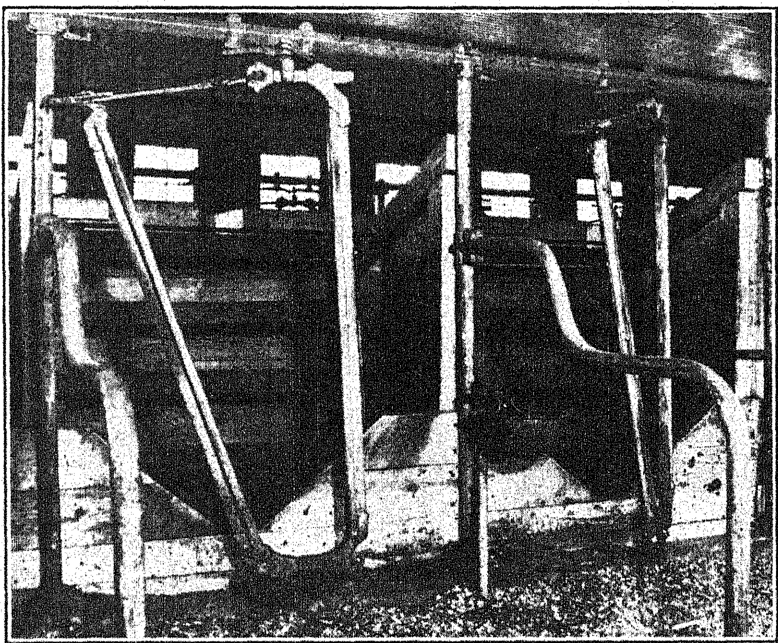
Considerable difficulty has been experienced with losses of feed when conducting feeding experiments with dairy animals. When the amount of feed is restricted the head of the animal may be closely confined for a sufficiently long time to allow the animal to eat and by so doing insure against any considerable loss of feed; however, when the animal is fed to the limit of her capacity, eating requires considerable time and she must have enough freedom to insure comfort, therefore losses of feed are difficult to prevent.

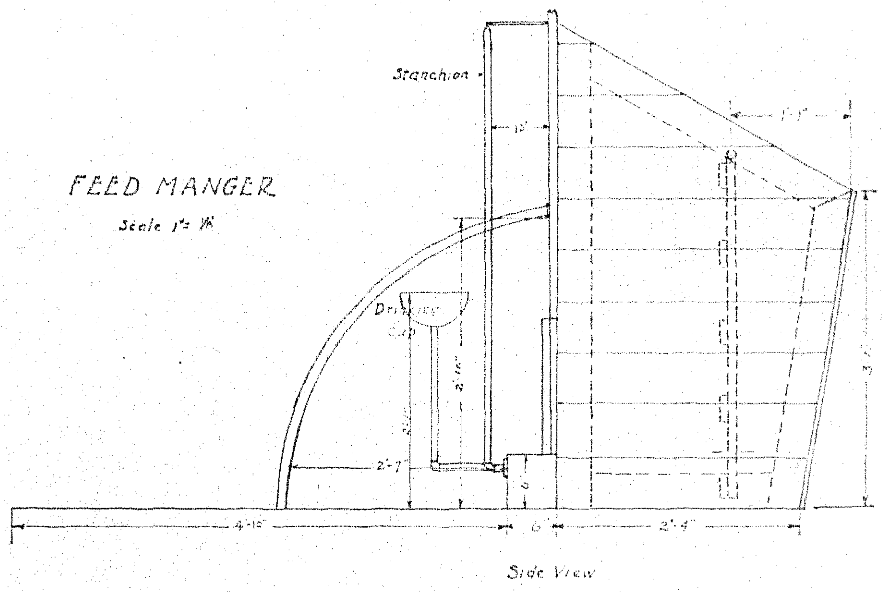


The accompanying diagram shows a manger that has proved satisfactory in use under the latter conditions. The mangers were built in sections long enough to provide individual mangers for three stalls. These were built and then set in place before the stalls. Two features distinguish these mangers from those that have been used commonly heretofore. First, a swinging rack or frame is suspended from a horizontal rod thirteen inches from the

Received for publication April 14, 1938.

[1] Acknowledgment is gratefully made to Mr. A. G. Foster of the Agricultural Engineering Department for the accompanying sketch.

extreme front of the manger and high enough so that it will swing clear of the floor. The frame is made up of 1″×3″ oak boards with the horizontal boards six inches apart. The hay is placed in the manger ahead of the frame and must be pulled through between the horizontals a mouthful at a time. The frame prevents the animals from throwing the hay over the front of the manger and is easily swung to the rear to clean the manger. Only one animal of twelve using the mangers draws enough hay through the frame to scatter appreciable quantities in the front part of the stall around her front feet, and even then the scattered material contains no leaves which drop in the manger. Two by six planks nailed to the manger divisions above the



concrete curbing are notched to form a V before the stanchion so that the cow may lie down comfortably with her head in the manger. The amount of hay strewn in the stall is reduced by having the rear of the manger built up higher. The higher rear manger partition also prevents the frame from swinging backward too far. The watering cups are located behind the manger and under the stall division, thus preventing spillage of water on refused feed which must be weighed back. The stanchions which are in use here may be adjusted according to the length of the animals to align the animals with the gutter. These must be adjusted to the extreme rear to allow the stanchion to swing freely behind the rear manger partition, if the cows are stabled for long periods of time.

These inexpensive mangers have largely eliminated experimental error due to losses of hay.

FEED UNITS FOR LACTATION, WORKING MAINTENANCE, AND GAIN IN LIVE WEIGHT IN DANISH DAIRY COWS

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The Agricultural Experiment Station at Copenhagen, Denmark, has published (1) the results of an extensive series of feeding experiments, conducted on a number of privately owned farms, to ascertain the effect of light to heavy feeding on milk yield. The plane of feeding was varied with respect to total feed units with total protein constant, and with respect to total protein with total feed units constant. In general these experiments were planned, using the feeding standard, $FU = .4FCM + (1.5 + .005W) + 4\Delta W$, as a guide.[1]

The feed intake is reckoned in the Danish work in terms of feed units. One feed unit is the equivalent of one kilogram of barley. In American units we may say one feed unit = 1.72 pounds of digestible nutrients, and one feed unit per kilogram (FCM, etc.) = .78 pounds of digestible nutrients per pound (FCM, etc.).

The Danish feeding standard given above has three components: $FU' = .4FCM$; $FU'' = 1.5 + .005W$; $FU''' = 4\Delta W$. The FU″ term is of special interest. It practically places the feed of working maintenance as proportional to the 2/3 power of live weight. The following numerical example will serve to show this:

$W =$	400	450	500	550	600
$FU'' = 1.5 + .005W =$	3.50	3.75	4.00	4.25	4.50
$FU'' = .0635W^{2/3} =$	3.45	3.73	4.00	4.26	4.52

Thus, within the live weight range of its intended application the working maintenance standard is proportional to the 2/3 power of live weight.

PURPOSE OF THIS PAPER AND RESULTS

It is proposed to apply the equation,

$$FU = aFCM + bW^{c} + d\Delta W \qquad (2)$$

Received for publication March 23, 1938.

[1] Symbols are used (except as noted) to apply to each experimental period for each cow, as follows:

FU = nutrients intake, feed units per day.
FU′ = nutrients apportioned to lactation, feed units.
FU″ = nutrients apportioned to maintenance, feed units per day.
FU‴ = nutrients apportioned to gain in weight, feed units.
FCM = milk-energy yield, kilograms of 4 per cent milk per day.
W = average live weight, kilograms.
ΔW = gain in live weight, kilograms per day.
n = number of cows or records.

to the data as given in Tables 15–40 of the Danish report. The published data include for each cow and each experimental period: the average feed intake in feed units per day; the average FCM yield in kilograms per day; the average live weight in kilograms (average of initial and final live weights); the average gain or loss in live weight in kilograms per day.

Equation (2) is fitted to these observations according to the method of

TABLE 1

Feed units apportioned to lactation, working maintenance, and live-weight gain. Records of Red Danish cows from Royal Veterinary and Agricultural College, Copenhagen, in groups of 10 or 20. (See footnote, page 645, for explanation of symbols)

Group No.	Sign of ΔW	n	Live-weight limits, kg.	W	$FU' = aFCM$ a	$FU'' = bW$ 1000 b	$FU''' = d\Delta W$ d
1	−	10	381–418	407.1	.4993	5.94	1.536
2	+	20	396–423	413.4	.2850	10.56	.980
3	−	10	420–439	430.5	.6820	1.76	3.043
4	+	20	425–438	432.8	.3168	12.29	1.593
5	−	10	439–446	442.2	.5712	3.58	.053
6	+	20	439–447	443.3	.4590	6.70	4.060
7	−	10	446–450	448.2	.3480	10.68	2.158
8	+	20	447–460	453.4	.2671	12.64	.246
9	−	10	451–460	453.4	.3397	10.58	.186
10	−	10	460–465	462.8	.4556	7.35	.508
11	+	20	460–466	464.1	.5078	5.73	1.548
12	−	10	466–468	467.1	.3661	9.31	1.085
13	+	20	466–471	469.2	.4777	6.24	1.368
14	−	10	469–474	471.2	.6615	− .17	−1.866
15	+	20	472–476	473.4	.3839	9.08	1.241
16	−	10	475–481	477.5	.4332	7.06	− .556
17	+	20	476–481	478.2	.5656	5.15	− .910
18	−	10	482–486	483.6	.3030	10.09	.480
19	+	20	481–489	484.4	.5501	4.76	.003
20	−	10	487–493	489.7	.5419	7.21	1.104
21	+	20	489–495	492.3	.5346	4.93	.698
22	−	10	494–499	496.5	.5082	6.45	5.573
23	+	27	496–503	499.7	.4771	6.48	.480
24	−	10	500–505	501.6	.3904	7.81	−2.780
25	+	20	503–509	505.9	.4045	8.22	.653
26	−	10	505–513	509.8	.4271	8.40	2.757
27	+	20	509–513	511.1	.5119	5.84	− .030
28	−	10	513–518	515.2	.4411	7.26	− .439
29	+	20	513–519	515.8	.4127	8.36	− .192
30	+	20	519–526	522.5	.5527	4.32	2.577
31	−	10	518–527	523.7	.4112	7.04	−1.343
32	−	10	528–532	529.5	.5408	3.83	− .310
33	+	20	526–533	529.6	.4878	5.85	.101
34	+	20	533–540	536.6	.4635	6.98	− .706
35	−	10	533–541	537.4	.5151	5.62	1.805
36	+	20	540–551	545.6	.4638	5.55	3.185
37	−	10	542–550	546.0	.3492	9.07	−2.625
38	+	20	551–557	554.0	.4463	6.76	1.060
39	−	10	551–568	558.3	.4911	5.45	− .194
40	+	20	557–565	561.1	.3904	8.92	−1.159
41	+	20	566–590	575.6	.3545	9.72	.192
42	−	10	573–595	583.0	.4624	6.95	1.252
43	+	20	590–674	613.7	.5134	6.25	− .903
44	−	9	595–642	613.8	.2644	11.02	2.554

the preceding paper (2). The $+\Delta W$ records (cows with final live weight equal to or greater than initial live weight, $n = 447$) are arranged in order by W and divided into groups by successive 20's. The $-\Delta W$ records (cows with final live weight less than initial live weight, $n = 219$) are arranged in order by W and divided into groups by successive 10's. Each of these groups of records is fitted with the equation

$$FU = aFCM + K + d\Delta W \quad (1)$$

In equation (1) K represents bW^c of equation (2). Table 1 gives the constants of equation (1) for each group, but K is given, in the FU″ column, as 1000K/W. Figure 1 shows 1000K/W plotted against W. The correlation between the two is $r = -.00 \pm .10$. There is no need to fit $K = bW^c$, for this zero correlation indicates that $c = 1$ in equation (2). The a, b, and d constants of equation (2) are taken to be, respectively, the average of the a,[2] b, and d values of Table 1. This gives

$$FU = .451FCM + .00713W + .68\Delta W \quad (3)$$

DISCUSSION

It is of interest to compare equation (3), representing Red Danish cows in farm herds in Denmark, with the corresponding equation representing Guernsey, Holstein, and Jersey cows in Experiment Station herds in the United States (2). Equation (3) may be converted to terms of digestible nutrients and pounds by substituting DN for FU and multiplying through on the right by .78.

Comparison of the feeding standards, indicated by the Danish and American data, follows:

$$\text{(Danish)} \quad DN = .35FCM + .006W \quad (4)$$

$$\text{(American)} \quad DN = .28FCM + .009W \quad (5)$$

in which all terms are expressed in pounds (instead of kilograms). According to these results the Danish cow, as compared with the American, requires ¼ more digestible feed energy for lactation to produce a unit of milk energy, but ⅓ less feed for maintenance per unit live weight. A difference of this magnitude, if real, commands attention.

Can it be that the Red Danish cow is more sluggish and expends less energy in muscular and general body activity, thereby reducing the energy cost of maintenance? (The Danish data include ages from 2.56 years to 14.32 years, with one cow 24 years old, while in the American data cows under 5 years of age are excluded.) If we could substitute .006W for .009W in equation (5) it would mean a saving of 19 per cent in the overall feed cost of producing milk in the case of a 1000-pound cow giving 25 pounds of 4 per cent milk per day.

[2] The correlation between a and W of Table 1 is $r = -.06 \pm .10$, and the coefficient of regression of a on W is $-.00011 \pm .00019$.

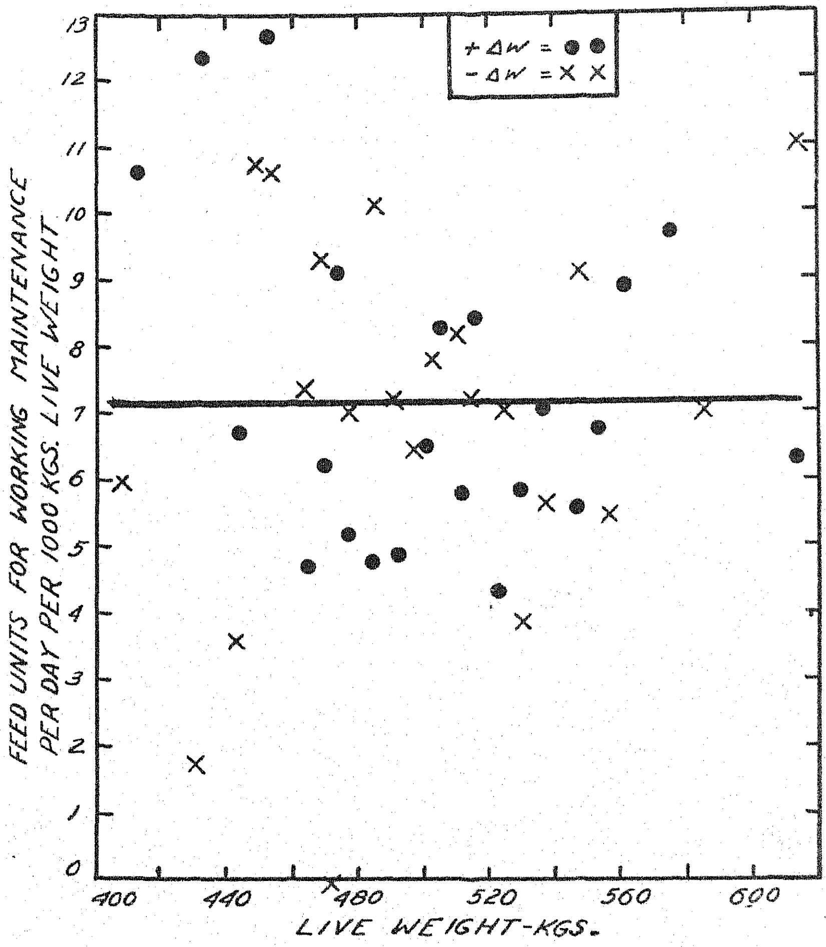

FIG. 1. Relation of working maintenance per unit live weight to live weight, from Table 1. The equation of the curve is $y = 7.13$, the correlation between x and y being $r = -.0049$.

Can it be that the Red Danish cow is not so highly developed as a dairy cow, and the mammary gland expends more energy to produce a unit of milk energy? Records of Red Danish cows show little or no relation between size of cow and amount of milk yield, while in American cows there is a decided relation, approaching direct proportionality in some cases. Any breed of cows that fails to show a relation between size and yield cannot be considered fully developed from a milking standpoint. That is, the activity in milk secretion has not progressed to a point where it taxes the strength of the cow.

Can it be that the difference between equations (4) and (5) is due to the

use of inadequate data or methods? Some of the limitations in this regard have been previously mentioned (2, 3). As the case stands it seems that feeding standards for cows in milk need to be adapted to the particular breed or kind of cow with which we are dealing. In practice the feeding standard affords the basis of formulating a trial ration. Adjustment may have to be made for the individual cow, according to her response in milk yield and gain in live weight. It is evident that while ΔW and $d\Delta W$, as used in the equations, are small in magnitude they may be large in physiological significance. Note the prevalence of minus d's in Table 1 and their drift to the larger W's. Undoubtedly more trustworthy results could be obtained from the present method of analysis if the experiments were designed for the purpose. Nevertheless, the data and analysis, as they stand, warrant tentative conclusions.

SUMMARY AND CONCLUSIONS

Six hundred sixty-six records of Red Danish cows on farms in Denmark are analyzed to apportion the nutrients consumed between lactation, working maintenance, and gain in live weight.

A feeding standard derived from the records disagrees in some respects with the standard which guided the feeding of the cows. Notably, the standard used assigns nutrients for working maintenance proportional to the $\frac{2}{3}$ power of live weight, while the present analysis of the records shows the nutrients for working maintenance are proportional to live weight.

The present standard from records of Red Danish cows, compared with the standard similarly derived from records of Guernsey, Holstein, and Jersey cows in Experiment Station herds in the United States, shows a great difference, as follows:

(Danish) .... $DN = .35FCM + .006W$

(American) .... $DN = .28FCM + .009W$

where DN is digestible nutrients consumed, pounds per day; FCM is milk energy yield, pounds of 4 per cent milk per day; W is live weight of cow, pounds. It is tentatively concluded that the Red Danish cow is not so well developed as a milking cow, requiring more feed energy for lactation per unit of milk energy produced, but, on the other hand, is a more sluggish cow requiring less feed energy for working maintenance per unit live weight. A feeding standard for cows in milk needs to be adapted to the particular breed or kind of cows for which it is used.

The Danish and American data agree in indicating that working maintenance is proportional to live weight, and not to a fractional power of live weight.

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THE USE OF RECORDS IN EVALUATING THE INHERITANCE OF COWS AND IN THE PROVING OF BULLS

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With the Herd Improvement Registry test of all the dairy breeds continually increasing and with the Dairy Herd Improvement Association program maintaining its popularity, there has been increasing attention devoted in recent years to lifetime production records. In some instances, national Breed Associations have granted special honor to cows that during their entire lifetimes, produced certain quantities of milk and butterfat. Cows that have produced one-hundred thousand pounds of milk in their lifetimes, often have been given special awards and in local associations and shows, liberal recognition has been bestowed upon lifetime champions. Frequently, special classes have been offered for "Ton" cows and for "Two Ton" cows, that is, cows which have produced a ton or two tons of butterfat during their lifetimes. With this increasing attention being given to lifetime production, the tendency has been in some instances to discount and discredit individual records.

There is no question but that any cow which has produced one or two tons of butterfat during her lifetime is deserving of recognition as she has undoubtedly been a profitable dairy animal. It is true that cumulative production indicates that a cow has been a financial asset to the herd. In view of this emphasis on lifetime yields, it seems that a study of the contribution such cows have actually made toward herd and breed improvement is needed. Is it possible that as a basis for genetic study, the use of lifetime averages tends to reduce variation and to distort to some extent the inferences that would be drawn from such data? With the high probability that over a period of years some uncontrollable factor will interfere with the producing ability of a cow, is there a tendency to introduce this environmental influence if average records are used? During the past decade, the results of much research have been published indicating that the production record of a cow considered alone is a poor measure of the cow's possible transmitting ability. Most of the publications on this subject have considered only one record.

The question now arises, is the average of two, three, four or more records any better index as to a cow's transmitting ability than is one record? There are also other related questions that are pertinent at this time. If dam and daughter comparisons are used in attempting to evaluate the transmitting ability of a bull, should the highest records of each dam and daughter be compared; or should the two year old records of the dam and daughter be

Received for publication March 17, 1938.

compared; or should a comparison be made between the average of all the records completed by each dam and each daughter? The latter method is the one most frequently used in Dairy Herd Improvement Association work. Then, what is the correlation that exists between one record and another record made by the same cow? Does the first record completed by a cow give much indication as to what she will produce in subsequent lactations barring illness or accident? If a cow has completed several records, does the first lactation record or does the highest record give a better indication as to the lifetime production?

In an attempt to throw further light on these questions, the Register of Merit and Herd Improvement Registry records of Jersey cows have been studied. In analyzing the records, it was first attempted to determine the repeatability of records made by Jersey cows. There were 197 cows which had completed five or more 305 or 365 day Register of Merit records. First, each record completed by each cow was converted to a mature 365 day equivalent basis using the age conversion factors previously tabulated and published by the American Jersey Cattle Club. Then the correlation between the first and second records completed by each cow was determined. Similarly, the correlation coefficients were determined between the second and third, the third and fourth, and the fourth and fifth records for each cow. Next, a comparison was made between the first record completed by each cow and the average of the next four records. Likewise, correlations were tabulated between the first record completed and the average of all five records and lastly, the highest record of each cow was compared with the average of all

TABLE 1

Correlation coefficients between records made by the same cow

(197 cows with 5 or more R. of M. records used)

Comparisons and correlations made	Coefficient of correlation	No. of + variations	No. of − variations	Av. + and − variation
Comparison of 1st R. of M. record with 2d record	$+0.71 \pm .024$	65	132	+ 57 − 103
Comparison of 2d R. of M. record with 3d record	$+0.77 \pm .020$	109	88	+ 71 − 80
Comparison of 3d R. of M. record with 4th record	$+0.69 \pm .025$	99	98	+ 85 − 86
Comparison of 4th R. of M. record with 5th record	$+0.59 \pm .031$	98	99	+ 102 − 94
Comparison of 1st R. of M. record with average of next 4 records	$+0.62 \pm .030$	72	125	+ 57 − 103
Comparison of 1st R. of M. record with average of all 5 records	$+0.75 \pm .021$	74	123	+ 46 − 86
Comparison of highest R. of M. record with average of all 5 records	$+0.92 \pm .007$	197	0	+ 99 − 0

five records. Also, the average variations were determined for each comparison. The results are shown in Table 1.

The results of the first four comparisons show that in comparing individual records, the greatest correlation exists between the second and third records completed. Also, the average variations are less between the second and third records. All of the coefficients of correlation are very good showing a relatively high degree of repeatability between normal records made by the same cow. The last three comparisons are significant. Less correlation existed between the first record completed by a cow and the average of the next four records, than between the first and second records. When the first record was correlated with the average of all five records, the correlation was still higher for, in this instance, the first record was included in making the average for the five records. The correlation between the highest record completed and the average of all five records is extremely high and indicates that the highest record completed by any cow gives a very good estimate as to what the lifetime average will be provided the cow is kept on test continuously and encounters no disease or misfortune. It should be mentioned that in 147 instances of the 197 cows used for analysis, the first Register of Merit records were begun at under three years of age, indicating first lactation records. In nearly all cases, the subsequent records were made in consecutive lactations.

Next, exactly the same comparisons were made using 166 cows that had finished five or more consecutive, complete Herd Test lactations. These results are shown in Table 2.

TABLE 2

Correlation coefficients between consecutive Herd Test records made by the same cow
(166 cows with 5 or more Herd Test records used)

Comparisons and correlations made	Coefficient of correlation	No. of + variations	No. of − variations	Av. + and − variation
Comparison of 1st Herd Test record with 2d record	+ 0.78 ± .021	70	96	+ 111 − 60
Comparison of 2d Herd Test record with 3d record	+ 0.80 ± .019	89	77	+ 75 − 87
Comparison of 3rd Herd Test record with 4th record	+ 0.75 ± .023	102	64	+ 98 − 54
Comparison of 4th Herd Test record with 5th record	+ 0.83 ± .016	121	45	+ 78 − 76
Comparison of 1st Herd Test record with av. of next 4 records	+ 0.80 ± .019	105	61	+ 93 − 49
Comparison of 1st Herd Test record with av. of all 5 records	+ 0.88 ± .012	104	62	+ 74 − 39
Comparison of highest Herd Test record with av. of all 5 records	+ 0.92 ± .008	166	0	+ 98 − 0

The correlation coefficients in this table differ just slightly from the similar comparisons made on the cows with Register of Merit records. In most instances, the correlation coefficients are a little higher than shown in Table 1. This result was not unexpected for most Herd Test records are made on a lower level of production than Register of Merit records, which naturally tends to reduce the variation from the individual records and this reduction in variation may tend to increase the correlations. It will be observed that all of the correlations are exceptionally good and that the highest record completed shows a remarkable correlation with the average of all five lactations.

The results thus far have shown that the highest record completed by a cow is a good indication of her potential lifetime production, barring accident, disease, or other misfortune. However, in addition to indicating the economic worth of a cow as a producer in the herd, production records are also used in the proving of sires and in estimating a cow's transmitting ability. The great lifetime producing cows with a number of records to their credit and high lifetime production totals, have been profitable dairy animals but it is important to learn their contribution to their progeny and descendants. Have they made any more contribution than cows which have completed only one or two high records? It is undoubtedly true that there are instances of cows having been injured physically, due to over feeding while making a record, and it is also true that some of the cows which have completed exceptionally high records have not been tested again. Consequently, in such instances, these cows are credited with only one record. In most cases, nothing is known as to why these cows were not tested again and not given the opportunity to see what they might have done during an entire lifetime. Sometimes, such cows have been held up to ridicule as having made no contribution at all to the breed, while other cows that have not been able to produce nearly as much in a single lactation, but which having been tested year after year and amassing fair lifetime yields, have been pointed to with pride.

It seemed worth while to study the transmitting ability of the lifetime production champions and also the transmitting ability of cows which for some reason had only been tested once but which had completed an exceptionally high yield. In the Jersey breed, there are 176 cows that have completed five or more 305 or 365 day Register of Merit records and which also have at least one officially tested daughter. This group was divided into two divisions. The first division of 87 cows with five or more records had lifetime productions of less than three-thousand pounds of butterfat. Two comparisons were made on this group. First, the lifetime production was divided by the number of lactations giving the average yield for each record. This average yield for the records completed by each cow was then compared with the average yields of the daughters' records. The average of all the records

completed by each dam was 485.51 pounds of fat and the average of all the daughters' records was found to be 558.26 pounds of fat. In the second comparison, the highest record completed by each of the dams was compared with the highest record completed by the daughters. When the highest record of each dam was selected and the average obtained for the 87 cows, it was found to be 590.52 pounds of fat. The highest records of the daughters when averaged was found to be 583.81 pounds of fat. In this analysis, it should be mentioned that the average production of all the mature (6 to 10 years) 365 day Register of Merit records that have ever been completed is 556.50 pounds of fat..

The second group consisted of 89 cows with five or more Register of Merit records but with lifetime totals exceeding 3,000 pounds of butterfat. All 89 cows had officially tested daughters. The same two comparisons were made on this group as with the first group, namely, the average of the dams' records was compared with the average of the daughters' records and then the highest record of each dam was compared with the highest records completed by the daughters. The average of all the dams' records was 622.27 pounds of fat and the average of all the records completed by the daughters was 612.07 pounds. When the highest record completed by each dam was selected and these high records averaged for the 89 dams, the result was 777.87 pounds of butterfat. This figure was then compared with the average of the highest records completed by all the tested daughters which was found to be 647.13 pounds of butterfat. It is obvious that the daughters of the cows with lifetime records of over three-thousand pounds of butterfat have exceeded the breed average considerably in production, while the daughters of the cows with lifetime records totalling less than three-thousand pounds of butterfat have just equalled the average for the breed.

It was then ascertained that to October 1st, 1932, a total of 219 cows had been tested just once for the Register of Merit and had completed a single record exceeding 740 pounds of butterfat. No information is available as to why these cows were never entered on test again. It may be that in some instances, the cows did not calve normally again, although it was ascertained that 115 or fifty-three per cent of these cows did calve immediately after the completion of their records and qualified for Class AA or Class AAA and in 172 instances or seventy-nine per cent, calves born after the completion of the record were registered from these cows. There were 118 or fifty-four per cent of the 219 cows with two or more registered progeny born after the dam completed her high record. It seems obvious that in most instances these cows were owned by breeders who did not follow a continuous year after year testing program as was the case with the owners of the preceding group of lifetime champions. This is indicated by the fact that only 88 of these cows with one record exceeding 740 pounds of butterfat have officially tested daughters. The records of these 88 cows were averaged and the result was

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It seemed worth while to study the transmitting ability of the lifetime production champions and also the transmitting ability of cows which for some reason had only been tested once but which had completed an exceptionally high yield. In the Jersey breed, there are 176 cows that have completed five or more 305 or 365 day Register of Merit records and which also have at least one officially tested daughter. This group was divided into two divisions. The first division of 87 cows with five or more records had lifetime productions of less than three-thousand pounds of butterfat. Two comparisons were made on this group. First, the lifetime production was divided by the number of lactations giving the average yield for each record. This average yield for the records completed by each cow was then compared with the average yields of the daughters' records. The average of all the records

completed by each dam was 485.51 pounds of fat and the average of all the daughters' records was found to be 558.26 pounds of fat. In the second comparison, the highest record completed by each of the dams was compared with the highest record completed by the daughters. When the highest record of each dam was selected and the average obtained for the 87 cows, it was found to be 590.52 pounds of fat. The highest records of the daughters when averaged was found to be 583.81 pounds of fat. In this analysis, it should be mentioned that the average production of all the mature (6 to 10 years) 365 day Register of Merit records that have ever been completed is 556.50 pounds of fat..

The second group consisted of 89 cows with five or more Register of Merit records but with lifetime totals exceeding 3,000 pounds of butterfat. All 89 cows had officially tested daughters. The same two comparisons were made on this group as with the first group, namely, the average of the dams' records was compared with the average of the daughters' records and then the highest record of each dam was compared with the highest records completed by the daughters. The average of all the dams' records was 622.27 pounds of fat and the average of all the records completed by the daughters was 612.07 pounds. When the highest record completed by each dam was selected and these high records averaged for the 89 dams, the result was 777.87 pounds of butterfat. This figure was then compared with the average of the highest records completed by all the tested daughters which was found to be 647.13 pounds of butterfat. It is obvious that the daughters of the cows with lifetime records of over three-thousand pounds of butterfat have exceeded the breed average considerably in production, while the daughters of the cows with lifetime records totalling less than three-thousand pounds of butterfat have just equalled the average for the breed.

It was then ascertained that to October 1st, 1932, a total of 219 cows had been tested just once for the Register of Merit and had completed a single record exceeding 740 pounds of butterfat. No information is available as to why these cows were never entered on test again. It may be that in some instances, the cows did not calve normally again, although it was ascertained that 115 or fifty-three per cent of these cows did calve immediately after the completion of their records and qualified for Class AA or Class AAA and in 172 instances or seventy-nine per cent, calves born after the completion of the record were registered from these cows. There were 118 or fifty-four per cent of the 219 cows with two or more registered progeny born after the dam completed her high record. It seems obvious that in most instances these cows were owned by breeders who did not follow a continuous year after year testing program as was the case with the owners of the preceding group of lifetime champions. This is indicated by the fact that only 88 of these cows with one record exceeding 740 pounds of butterfat have officially tested daughters. The records of these 88 cows were averaged and the result was

790.72 pounds of fat. It will be noted that this average is just slightly higher than the average of the highest records completed by each of the second group of great lifetime producers. Next, the records of the daughters of these 88 cows were studied and two tabulations made. First, all of the records completed by each daughter were averaged and the average was found to be 639.53 pounds of fat. In the second tabulation, the highest records of all the daughters were averaged and the result was 651.43 pounds of butterfat. These tabulations are all given in Table 3.

TABLE 3

High lifetime record cows and high individual record cows and the records of their progeny

	Average of all records completed by each cow	Average of highest records completed by each cow	Average of all records completed by all daughters	Average of highest records completed by all daughters
87 cows with 5 or more R. of M. records totalling less than 3000 lbs. of fat and having tested daughters	485.51	590.52	558.26	583.81
89 cows with 5 or more R. of M. records totalling more than 3000 lbs. of fat and having tested daughters	622.27	777.87	612.07	647.13
88 cows with only one record and that record above 740 lbs. fat, and having tested daughters		790.72	639.53	651.43

Of principal interest is the fact that the daughters of these cows with only one high record show a slightly higher yield than do the daughters of the cows with lifetime records exceeding three-thousand pounds of butterfat. Apparently the daughters of the cows that have completed only one extraordinarily high record have themselves produced as well or better than have the daughters of the cows which during their lifetimes have produced more than three-thousand pounds of butterfat.

Previous work by numerous investigators has shown that the correlation existing between a dam's record and the daughter's record is relatively low. Correlation coefficients between dam and daughter records as published by Gowen (1), Turner (2), Gifford and Turner (3), and Smith, Scott and Fowler (4), range between +0.259 and +0.42. The following two tables illustrate the relationship existing first, between the average records of the dams with the average of their daughters' records and second, between the highest record of each dam and the highest records of her daughters.

In both of the preceding tables the relationship seems to be about the same and while there is some correlation existing between the records of the dams and the records of the daughters, the variation in the yield of each group of

TABLE 4

Comparison of average records of cows having 5 or more records with the average records of their tested daughters

Production divisions of dams	No. of comparisons	Av. yield of dams	Av. yield of daughters
700 lbs. and over	16	761	640
650 to 699 lbs.	14	675	617
600 to 649 lbs.	24	622	629
550 to 599 lbs.	27	573	607
500 to 549 lbs.	41	523	560
450 to 499 lbs.	30	476	548
400 to 449 lbs.	17	432	551
Under 400 lbs.	7	359	550
Total and averages	176	554	585

daughters was quite pronounced. This is best indicated by the fact that the coefficient of correlation between the highest records of the dams and the highest records of the daughters was found to be $+0.29 \pm .047$, while the correlation between the average records of the 176 dams and the average yield of their tested daughters was found to be $+0.30 \pm .046$. These correlations are most significant. While they are both quite low, they are practically the same and indicate that the highest record of a cow gives about as much information concerning a cow's possible transmitting ability for production to her

TABLE 5

Comparison of highest records of cows having 5 or more records with the highest records of their tested daughters

Production divisions of dams	No. of comparisons	Av. yield of dams	Av. yield of daughters
900 lbs. and over	12	979	688
850 to 899 lbs.	11	870	665
800 to 849 lbs.	14	823	663
750 to 799 lbs.	14	767	601
700 to 749 lbs.	24	725	672
650 to 699 lbs.	23	670	581
600 to 649 lbs.	31	626	591
550 to 599 lbs.	19	577	588
500 to 549 lbs.	15	530	544
Under 500 lbs.	13	457	579
Total and averages	176	685	614

daughters, as does the average of a series of records completed during an entire lifetime.

An item of interest in this connection is that the 197 cows with five or more Register of Merit records have an average of 6.05 registered progeny per cow, to date. The 219 cows with only one high Register of Merit record have an average of 4.70 registered progeny each, to date. It is realized that in both cases, these averages of progeny are not complete for in many instances

calves are still being registered from these cows and also very often male calves are not registered. In addition, in a number of cases, calves may have died before being recorded.

As a supplement to the data already presented, a study was made of the first calf heifers of the breed which had completed exceptionally high records. Prior to 1933, a total of 318 heifers starting test at two years nine months or under, have completed a Register of Merit record in excess of 600 pounds of butterfat. Of these 318 high record first calf heifers, 172 completed second records and 70 have completed three or more records. The first and second records were compared and the correlation coefficient was found to be $+.55 \pm .036$. This correlation while good is somewhat lower than the correlations between the first and second records shown in Table 1 and Table 2. When the records were computed to maturity, the first records of the 172 cows averaged 890 pounds of fat and the second records averaged 833 pounds of fat. It was then determined that 127 of these high record first calf heifers have tested progeny. The records of the cows and the records of their progeny were converted to a mature yearly basis. When the highest record of each cow was compared with the highest record of the daughters for the entire group, the correlation coefficient was found to be $+0.30 \pm .055$. This correlation is in agreement with the previous correlations between the highest record of the lifetime dams and daughters and the average records of the lifetime dams and daughters. The following table also helps illustrate the relationship existing between the highest records of these cows compared with the highest records of their tested daughters.

TABLE 6

Comparison of highest records of (high yielding) heifers with highest records of their tested daughters

Production divisions of dams	No. of comparisons	Av. yield of dams	Av. yield of daughters
1000 lbs. and over	22	1071	777
950 to 999 lbs.	15	970	770
900 to 949 lbs.	19	918	708
850 to 899 lbs.	29	870	704
800 to 849 lbs.	34	831	688
Under 800 lbs.	8	782	606
Totals	127	890	715

Twenty-eight of these high record heifers were the dams of "tested" bulls. The records of the twenty-eight dams averaged 957 pounds of fat and the records of the daughters of the twenty-eight sons averaged 636 pounds of fat. In the preceding group of cows with five or more records, nineteen were the dams of "tested" sons. The highest records of the dams averaged 864 pounds of fat and the sons' daughters' records averaged 627 pounds of

fat. The 317 high record first calf heifers have an average of 4.37 registered progeny each, to date, which is slightly less than the two preceding groups studied.

SUMMARY

In summarizing the results of both phases of the investigation, it seems apparent that given the opportunity and barring illness or injury, a cow capable of completing one good record should be able to complete a number of lactations with good yields and thus finish a lifetime with a creditable total production. This is not in any sense an argument against continuous year after year testing. Continuous testing is needed to prove bulls at the earliest possible age. Several records are often needed on many cows to secure one complete lactation in which everything including health, feeding and management, and climatic conditions are fairly normal. Records made following abortions, attacks of bloat, milk fever and mastitis infection, do not give a true picture of a cow's ability at all. Neither are the records made in some sections of the drouth area during recent years, a fair measure of a cow's actual ability. Furthermore, only by continuous testing can a breeder tell definitely when a cow has ceased to be a profitable member of the herd.

Because of the necessity to assay the transmitting ability of bulls at the youngest possible age, it is impractical to compare lifetime records of daughters with the lifetime records of their dams. If we compare the average of several records on the dams with the first lactation records completed by the daughters, the results may be misleading. In selecting bulls, if the practice of comparing the highest record of the daughter with the highest record of the dam is used, no allowance is then made for the probability that the daughters will better their early records in later life and this method should improve the chance of a breeder being correct in selecting proved sires. In other words, an additional safeguard is furnished by insisting that the daughters of a bull in one or two trials produce as well or better than their dams were able to do in perhaps five or six trials.

If a cow has completed one record of 600 or 700 pounds of butterfat, she obviously possessed the inheritance to produce that amount in a lactation, unhampered by illness, poor management, or drouth conditions and consequently it seems that one record, and preferably the highest record, is suitable for evaluating the sire's ability and in trying to measure the cow's transmitting ability. Breeding operations will be seriously handicapped if breeders are forced to wait until cows have finished a series of four or five or more records, in order to obtain worth while information as to the sire's ability or the cow's own possible transmitting ability.

It also seems apparent from the data presented, that neither the highest record nor the average of several records gives a great deal of information

concerning the cow's transmitting ability as measured by the correlation with the daughter's production. To attempt to measure this, additional information is essential, such as the records of a cow's sisters and the records of her daughters. In a previous paper by the author (5), it was concluded that the record of a cow together with the records of her daughters and the records of her sisters did give a fair estimate concerning her transmitting ability.

Lifetime productions are largely influenced by longevity, opportunity, and perhaps to a certain extent, good fortune. Little if any data have been published concerning the inheritance of longevity. Unfortunately this is often not determined by nature. A high percentage of cows culled from the herds are removed due to disease infection. Is there any reason to believe that a cow, descending from a line of long-lived ancestors, is more immune to mastitis, Bangs' infection, etc., than is the daughter of a cow living only long enough to complete one or two lactations? Udder attachment is also another factor affecting the length of time cows remain in herds and it may be that some cows with a high inherited producing ability have not inherited a sufficiently strong udder attachment to keep the udder from breaking away and becoming pendulous. However, feeding and management may also be partly responsible for udder troubles. The inheritance of high milk producing ability, longevity, breeding efficiency, disease resistance and strength of udder attachments, all contribute to the end product of profitable lifetime production. Yet, it seems that these are separate problems in themselves and the selection of the highest record of an animal is the best index as to that animal's actual inherited production capacity under normal conditions.

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FEED FLAVORS IN MILK AND MILK PRODUCTS

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The producer of milk is always confronted with the problem of preventing sour milk. With the increased consumption of milk and milk products has come the demand that milk not only be sweet but that it have a pleasing flavor. Milk containing an abnormal flavor is rejected by dealers and consumers. Dairymen are giving considerable attention to the prevention of losses due to sour milk. They too rarely recognize, however, that the production of milk containing objectionable flavors not due to souring is causing an annual loss probably greater than that from sour milk.

The fact that the feed consumed by the cow may be a contributing cause of abnormal flavors in milk has long been recognized. As early as 1829 William Harley (1) described a method for "preventing milk from tasting of turnips." He also observed, "It is chiefly common turnips and cabbages that give the strong taste to milk and butter." Many other early references are available dealing with the effect of feeds on the quality of milk. Almost without exception, in these early studies, quality was based on the chemical constituents of the milk. The effect of feeds on the flavor of milk was overlooked, or, if noted, dismissed with a sentence or two.

Although some work was reported prior to that reported by Gamble and Kelly (2), apparently it was the systematic study by the latter investigators on the effect of silage on the flavor and odor of milk that initiated recent interest in the subject. They reported a wide variation among individual normal cows in the flavor and odor of the milk produced. Cows receiving the same feed and care produced milk that ranged in flavor from pleasing to objectionable. Roadhouse, Regan, and Mead (3) confirmed the fact that there is a marked difference in the flavor of milk of individual animals and later Roadhouse and Koestler (4) reported on the causes of these variations in the flavor of milk from individual cows.

Gamble and Kelly (2) showed that in feeding corn silage before milking, when as little as 10 pounds was given at a feeding, the milk took on, through the body of the cow, a faint feed flavor and odor. As the quantity was increased to 30 pounds at a feeding, the degree of silage flavor and odor was likewise increased. This confirmed the work of Knisely (5), who reports that milk from cows fed corn silage has a more pronounced odor than milk from cows fed hay. King (6) also stated "It was demonstrated beyond

Received for publication July 30, 1938.

Editor's Note: This is the first of a series of reviews by recognized authorities on subjects of interest to the Dairy Industry.

question that when silage is fed a short time before milking, a sweetish odor is imparted to milk."

Gamble and Kelly (2) showed further that when as little as 30 pounds of corn silage was fed daily, in two feedings immediately after milking, the milk showed a slight feed flavor and odor; and that when more than 40 pounds was fed, the milk carried a slight silage flavor and odor continuously. Henry and Morrison (7) report that as the silage-feeding period progressed the effect of the silage became less and less apparent in the milk. Gamble and Kelly (2) showed that this applied, however, only when less than 35 pounds was fed per cow per day; it was shown that when over 40 pounds was consumed, the sweetish feed flavor could always be detected. From their work with corn silage they concluded that: (1) When silage is fed 1 hour before milking its taint is discernible in the milk. (2) Not over 15 to 25 pounds of corn silage can be fed twice daily after milking without imparting a discernible flavor and odor to the milk. (3) Silage should be fed immediately after milking.

In experiments with alfalfa, sweetclover, and soybean silages Gamble and Kelly (2) showed that legume silages should also be fed only after milking and then in quantities of not more than 15 pounds to a feed twice daily if milk reasonably free from feed taints is to be obtained. In regard to soybean silage, Woll and Humphrey (8) stated that satisfactory dairy products could not be made when cows were fed this silage, and Woodward and McNulty (9) reported that silage made from clover, while palatable, has an objectionable odor necessitating care in feeding to avoid tainting the milk.

Russell (10) states: "As milk is exposed during the milking process, and very often after its withdrawal to an atmosphere that is liable to contain odors of an undesirable character, it is not surprising to note that it may thus contract flavors by direct absorption." Ritland (11) expressed the opinion that the flavor noted in milk of cows fed turnips is due entirely to the absorption by the milk of volatile ingredients of the turnips. Farrington (12) says, "It has repeatedly been proved that silage can be fed to dairy cows without tainting the milk, butter or cream, in the slightest, but unless certain precautions are taken to prevent this, the cream or butter may be so tainted with silage smell that many customers will refuse to use it. The success of feeding silage depends almost entirely upon the disposition of the man feeding it, to constantly keep the air in the stable free from silage smell."

As a result of trials in which silage was spread on the floor underneath two cows in a stable with the doors and windows tightly closed, thereby exaggerating barn-air saturation, Gamble and Kelly (2) showed that silage-tainted barn air may have some effect on the flavor and odor of milk under such extreme conditions, but concluded that the effect would be relatively small under average conditions.

They further showed that careful and prompt aeration of the warm milk will remove silage flavors and odors permanently, if the milk was only slightly tainted, and will reduce the degree of the silage flavors and odors if the taint was more pronounced. This is in agreement with Marshall (13), who stated, "Odors and taints resulting from aromatic foods, physiological processes, and disease processes may be greatly reduced permanently," by aeration.

Other facts brought out by Gamble and Kelly (2) were: (1) Feeding moderate quantities of corn silage after milking and prompt aeration of the milk may in some cases actually improve the flavor of milk that would otherwise have a flat or insipid taste. (2) While silage odors in the barn air have only a slight effect on the flavor and odor of milk, it is best to provide adequate ventilation and to practice other sanitary measures to insure the finest possible flavors. (3) The feeding of badly decomposed or moldy silage imparts undesirable flavors to milk. (4) Cream from silage-tainted milk possesses and retains silage flavors and odors to a greater extent than the milk from which it is taken. (5) Condensed milk made from silage-tainted milk has a less perceptible silage flavor and odor than the milk from which it is made.

Babcock (14–18) confirmed the work of Gamble and Kelly (2) in that he found: Feed flavors are more pronounced in the cream than in the milk from which the cream is taken. Proper aeration reduces strong off flavors and odors in milk caused by feeding highly flavored feeds, and some of the slight off flavors and odors may be eliminated. Even highly flavored feeds may be fed immediately after milking without seriously affecting the flavor of the milk produced at the next milking.

He showed that when fed to dairy cows 1 hour before milking, green alfalfa, cabbage, turnips, rape, and kale seriously affect the flavor and odor of milk. Green rye, green cowpeas, potatoes, dried beet pulp, and carrots affect milk only to a slight degree. Green corn, green oats and peas, green soybeans, pumpkins, and sugar beets have practically no effect on the flavor and odor of milk. When dairy cows were fed 1 hour before milking time and consumed 15 pounds twice daily of those feeds that were found to affect seriously the flavor of milk, objectionable flavors and odors were produced in the milk. Increasing the consumption of these feeds to 30 pounds twice daily greatly increased the intensity of the abnormal flavors and odors. When these feeds were fed in quantities up to 30 pounds twice daily immediately after milking, they had practically no effect on the flavor and odor of the milk produced at the next milking. In fact, in the case of green alfalfa, it was shown that changing the time of feeding from 1 hour before milking to 3 hours before milking, decreased the intensity of the abnormal flavor, and feeding 5 hours before milking practically eliminated it. On the other hand, large quantities of feeds like cabbage and turnips, even though fed immedi-

ately after milking, may at times slightly taint the flavor of the milk produced at the next milking. These taints, however, are slight and would seldom be noticed by the average consumer. Feeds that had only a slight effect when fed before milking had no detrimental effect when fed after milking.

In order to show more conclusively that feed flavors enter milk mainly through the body of the cow and to determine the time required for flavors to enter the milk, Babcock (19) conducted feeding experiments with garlic. This work showed that garlic flavor and odor can be detected in the milk when the milk samples are taken 1 minute after garlic is fed. The intensity of the garlic flavor increases as the time interval between feeding the garlic and taking the milk samples increases, until at 10 minutes a high degree of intensity is reached. Garlic flavor is present to a very objectionable degree in milk from cows that have consumed one-half pound of garlic 4 hours before milking. Milk drawn 7 hours after the cows consume one-half pound of garlic is practically free from garlic flavor. Strong garlic flavor is found in milk drawn 2 minutes after the cows inhale garlic odor for 10 minutes and practically disappears in 90 minutes after such inhalation. Garlic odor is readily perceived in samples of blood drawn 30 minutes after the cows are fed 2 pounds of garlic tops and strong garlic odor is present in the blood drawn 45 minutes after such feeding, indicating that the flavor is transmitted by the blood to the udder.

His work with bitterweed (20) further confirmed the fact that flavors enter milk mainly through the body of the cow. This weed is frequently found in southern pastures and, although it is practically odorless, it imparts its flavor to the milk when the cows eat it. Work with this weed also showed it to be an exception to the usual rule "that feed flavors are more pronounced in cream than in the milk from which the cream is taken," the flavor produced by bitterweed being more pronounced in skim milk than in whole milk and much less pronounced in the cream than in the skim milk. It further showed that there also may be exceptions to the rule that "feed flavors are not imparted to milk except for a few hours after feeding." When cows consume 10 pounds of bitterweed the flavor is present in the milk produced 24 hours later, but milk produced 27 hours later is practically free from a bitter flavor.

Babcock (21) summarizes his work by stating: "Proper methods of feeding are essential to the production of palatable milk. In most cases feed flavors are not imparted to milk except for a few hours after feeding. For this reason dairy cows should be given highly flavored feeds immediately after milking, never just before. When consumed in large quantities, feeds such as cabbage, which has an unusually strong flavor and odor, occasionally affect the quality of milk for 12 hours after feeding; but the intensity of the flavor has usually decreased to such an extent that it would not be noticed by the average consumer." He further states: "Proper aeration and cooling reduce strong feed flavors and odors and sometimes eliminate slight flavors

and odors. Therefore, when the practice of feeding immediately after milking is followed by proper aeration of the milk, most highly flavored feeds will not make the milk unpalatable.''

Some of the feeds studied by Babcock (14–18) are mentioned in earlier literature. Vandenhoydonck (22) reports a case in which the cause of a bitter flavor in milk was located in the feeding of Swedish turnips which had been washed in foul ditch water. Dammann (23) says ''Bitterness in milk is often due to feedstuffs such as oat straw, turnip roots, cabbage, rapeseed cake, wormwood.'' Dean (24) reports feeding cows 3 pecks (41 pounds) of turnips per day with the result that a slight taint was noted in the milk. When 4 pecks (55 pounds) were fed, the milk had a decided taste of turnips. Pasteurization and added starter prevented this taste from being carried to the butter. He also reported that the flavor of butter was slightly better from mixed feed than from silage feed. Lindsey, Holland, and Smith (25) report that the feeding of dried distillers' grains or brewers' dried grain in quantities of from 3 to 4 pounds per cow per day did not affect the flavor of the milk, and regarding the feeding of beet pulp Reece (26) reports that the milk showed no uncommon flavor of any kind when 10 pounds per head per day of the best pulp slices were being fed to cows at 4 important English agricultural colleges.

The results obtained by Gamble and Kelly (2) and by Babcock (14–21) have been confirmed and extended by other investigators. Davies (27) reported that the feeding of dried beet pulp sometimes causes a fishy or off-flavor in milk. Hening and Dahlberg (28) found no abnormal flavors due to feeding mangels or dried beet pulp and at the same time concluded that these feeds in no way prevented or increased the susceptibility of milk to the development of oxidized flavor.

Roadhouse and Henderson (29) state that ''full rations of alfalfa hay, green alfalfa, clover hay, or corn silage fed 1 to 2 hours before milking produced strong, undesirable feed flavors and odors. As the interval between feeding and milking increased, the intensity of the feed flavors decreased. When these feeds were withheld during the 5-hour interval before milking, objectionable feed flavors and odors were eliminated.'' These authors also found that when green barley, wild oats, foxtail, and filaree were fed to cows 2 hours before milking, in quantities required for satisfactory nutrition and as a sole source of roughage, undesirable feed flavors varying from slight to strong were imparted to the milk in every instance. Tame oat hay gave only slight after-flavor in milk when 8 to 9 pounds was fed to cows 2 hours before milking. When fed in a mixture with 7 pounds of alfalfa hay, it did not modify the intensity of the alfalfa flavor. Improperly cured hay having a musty odor transmitted a musty flavor to milk.

Studying the concentrates, these same investigators state ''The usual concentrate feeds—rolled barley, coconut meal, soybean meal, cottonseed

meal, wheat bran, and dried beet pulp—when fed 1 or 2 hours before milking, in quantities used by the average commercial dairyman, did not give milk sufficient flavor to make it undesirable to the average consumer. Rolled barley and beet pulp, however, fed alone in 5-pound quantities or more, 1 and 2 hours before milking, gave either a detectable flavor or after-flavor; but the judges believed that these would not be noticed in cold milk by the average consumer. Wheat bran seemed to improve the flavor of the milk when fed in 5½ to 7 pound quantities 1 hour before milking. It gave more flavor to the milk than was present in the control samples, and the flavor was reported as pleasing.''

In a study to determine the rate at which the juice of the alfalfa plant made its appearance as a feed flavor in the milk, Roadhouse and Henderson (30) concluded: ''Feed flavor appears in milk 20 minutes after the ingestion of flavor-producing materials in liquid form. The most pronounced feed flavor was present in the milk drawn 45 to 60 minutes after drenching.''

These same investigators (Roadhouse and Henderson) (31) found that when cows were fed alfalfa hay as roughage immediately after milking or were given access to alfalfa pasture both day and night for the entire interval between milkings, they did not consume sufficient feed during the last 5 hours before milking to seriously affect the flavor of the milk. When they were given access to the pasture only, during the interval between morning and evening milkings, they consumed sufficient feed during the 5-hour interval before milking to cause an objectionable feed flavor in the milk. Under these conditions they recommend that the cows be removed from the pasture 4 or 5 hours before milking if feed flavor in milk is to be entirely avoided. They also recommend that if large amounts of corn silage are used in the ration it be fed after milking.

Lucas (32) stated ''Alfalfa hay gives to milk a rather pronounced flavor but it is objected to only by a very few people.'' Weaver, Kuhlman, and Fouts (33) concluded from their work with alfalfa hay that: ''Alfalfa hay fed less than four hours before milking has a pronounced effect on milk flavor. This effect is observed even when the interval between feeding and milking is only one-half hour. The two-hour interval causes the most serious flavor in the milk. If the hay is fed as long as four hours before milking the flavor is entirely eliminated with some cows. With other cows it is so reduced as to be scarcely discernible. Aeration of the milk removes some of the flavor but does not entirely eliminate it. Cooling seems to be ineffective and the effect of alfalfa hay is far more serious than that of darso silage.''

The important part which feeds play in the flavor of milk has been further exemplified by Weaver, Fouts, and McGilliard (34). These investigators have shown that feed flavors are the most prevalent of the numerous flavor defects encountered in milk.

SUMMARY

The investigators on the effect of feeds on the flavor and odor of milk have shown that:

Many feeds impart their flavor to milk, the intensity of the imparted flavor depending upon the character of the feed, quantity consumed, and the time the feed is consumed in relation to the time of milking.

Feed flavors enter milk mainly through the body of the cow and in most cases these flavors are not imparted to milk except for a few hours after feeding.

Strong feed flavors are reduced in intensity and slight flavors may be eliminated by proper aeration.

Highly flavored feeds should be fed immediately after, never just before, milking.

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American Dairy Science Association Announcements

HUBERT EVERETT VAN NORMAN

JANUARY 30, 1872–JULY 28, 1938

Hubert Everett VanNorman, a professor of Dairy Husbandry and a prominent executive in educational and industrial institutions, died in Chicago, Illinois, on July 28, 1938.

Few men who have started their careers in the classroom and held prominent executive positions in educational institutions have been able to devote as much time to leadership in the dairy industry. He was reared on a dairy farm and with that background he had the interests of the dairy farmer at heart. During the years he was connected with educational work, he would turn aside his collegiate duties at any time to speak to dairy gatherings or attend dairy industry meetings in which he always took a prominent part. He was a clear, inspiring speaker. This quality and his broad experience in the dairy industry led to the continual demand for his services by dairy organizations. He once remarked that his greatest ability seemed to be as a speaker and a starter of new enterprises.

Dr. VanNorman was born at Tillsonburg, Canada, and came to the United States in 1880. He was graduated from the Michigan Agricultural College in 1897 and served as assistant buttermaker during his college course. After graduation he accepted a position at Purdue University as farm superintendent and instructor in dairying and was advanced to Chief of the dairy department in 1902, which position he held for four years. While at Purdue, he served for seven years as Secretary of the Indiana Dairy Association. In 1905 he became Professor of Dairy Husbandry at the Pennsylvania State College and was Head of the Department until 1913 when he resigned to accept a position with the University of California as Professor of Dairy Management, Vice-director of the Agricultural Experiment Station and Dean of the University Farm School.

While at Pennsylvania State College, Dr. VanNorman was active in improving the College instruction and was the author of the text book "Firs
Lessons in Dairying." During these years he took a prominent part in st ate
and national dairy association affairs and served as President of the P enn-
sylvania Dairy Union, secretary of the Agricultural Federation of P ennsyl-
vania and Vice-President of the National Dairy Show in 1907–8. He was
secretary and manager of the National Dairy Show for two years and finally
president in 1911, which honor he held until 1922. While pre sident of the
National Dairy Show, Dr. VanNorman contributed much to the progress of
dairying and the dairy industry. His speaking ability d dignity on the
speaking platform brought him before many of the i y conventions and
he held the dairy cattle equipment and machiner izations together for

many years in a unified Dairy Exposition. During these years he served also as a director of the National Dairy Council and he was a charter member of the American Dairy Science Association. Although Dean VanNorman's duties were arduous in California in developing a recently established school of agriculture, he found time to attend meetings of the directors of the National Dairy Show and to spend a week at the Show to fulfill his responsibilities as president.

In 1921 plans were being made in Washington to invite the World's Dairy Congress to meet in the United States. Dean VanNorman was asked to serve as organizer and manager of the Congress. This important undertaking required the services of a man of ability in leadership who was well known to the dairy industry, and Dr. VanNorman was a happy selection for this important position. To assure representation of European countries at the Congress, Dr. VanNorman visited many countries in Europe and extended personal invitations. The Congress which was held in Washington, Philadelphia, and Syracuse in 1923, was splendidly organized and carried out. At the close of the Congress at Syracuse, the University of Syracuse conferred upon Dean VanNorman the honorary degree of Doctor of Laws.

In 1925 he was selected to organize the American Dry Milk Institute and he became its first president. In 1929 he resigned to become director of research for the Borden Company, which post he in 1903 left to take charge of the dairy industry exhibit at the Century of Progress Exposition in Chicago. At the close of the exposition Dr. VanNorman was Director of Development and Education for the Chicago Mercantile Exchange.

Those who knew Dr. VanNorman as a close personal friend, and who had been a guest in his home, realized his cordial and lovable nature.

VOLUME XXI OCTOBER, 1938 NUMBER 10

JOURNAL OF DAIRY SCIENCE

Published by the
AMERICAN DAIRY SCIENCE ASSOCIATION
R. B. STOLTZ
Ohio State University, Columbus, Ohio, Sec.-Treas.

ABSTRACTS OF LITERATURE

T. S. SUTTON, Editor
Columbus, Ohio

MILK AND MILK PRODUCTS

Published in cooperation with
INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS
R. C. HIBBEN, 1105 Barr Bldg., Washington, D. C., Exec. Sec.

INTERNATIONAL ASSOCIATION OF MILK DEALERS
R. E. LITTLE, 309 W. Jackson Blvd., Chicago, Illinois, Exec. Sec.

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SPECIAL PUBLICATIONS

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rch in Dairying,
and Milk In-

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

474. Prevalence and Classification of Hemolytic Streptococci in Pasteurized Milk. LAWRENCE W. SLANETZ, New Hampshire Agric. Exper. Sta., Durham, N. H. Tech. Bull. 70, January, 1938.

Routine analysis of the bacterial content of various samples of milk indicated that large numbers of weakly hemolytic streptococci were often present. In the present study an attempt was made to develop suitable methods and media for the detection and isolation of these streptococci and to determine their prevalence in pasteurized milk, their origin, and their identity.

These weakly hemolytic streptococci were absent in the pasteurized milk from only two of the nine dairies studied. Counts ranged from 200 to 270,000 per cc., and in nearly all cases were greater than the standard plate counts.

Sheep blood agar proved best suited for the detection and isolation of these bacteria. No apparent growth occurred on standard meat extract agar. Studies indicated the presence of the hemolytic streptococci in the raw milk before it reached the dairies, principally due to utensils which were not cleaned and sterilized thoroughly.

Sixty strains, classified into five groups, were identified and studied in detail. All were able to resist pasteurization temperatures and to produce colonies of the alpha prime type on blood agar.

Large numbers of these streptococci in milk are undesirable, and methods should be used for their detection and elimination. K.S.M.

475. Induced O/R Potentials, Rates of Growth and the Volatile Acid Production of Lactic Acid Bacteria in Milk. J. G. DAVIS, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. Dairy Research *9:* 85, 1938.

The abilities of type cultures of lactic acid bacteria to reduce five O/R indicators (methylene blue, Janus green, litmus, neutral red and safranine) were determined in plain milk and yeast dextrose milk. It is suggested that in some cases the reduction or non reduction of a dye may be used for identification purposes. Methylene blue, litmus and safranine may be of some value for this purpose. There was a marked correlation between rapidity of growth in milk, ability to reduce O/R dyes and the proportion of by-products. This relationship holds not only for the different groups and types, but also for variations in behavior observed in species kept under laboratory observation. It is suggested that rate of growth is fundamen-

tally related to the amount of by-products and hence presumably to flavor producing substances such as diacetyl and acetic acid. Thus in cheese ripening enforced slowness of growth may be as important as the presence of specific types.

S.T.C.

476. The Resazurin Test—A Preliminary Study. J. M. FRAYER, Vt. Agric. Exper. Sta., Burlington, Vt. Bull. 435, June, 1938.

Preliminary trials were conducted with this test on samples of milk as delivered at creamery receiving stations and of individual cows' milks, drawn as aseptically as possible. Comparisons were made with the methylene blue reduction test and with plate and cell counts. The degree of dependability, the effect of variation in dye concentration, and of light and cooling were also studied. All samples were tested using one milliliter of a .005 per cent solution of resazurin to 10 ml. of sample and one-hour incubation at 37 ± 1° C. (98.6° F.).

The resazurin test:

1. Correlated poorly with the methylene blue reduction test, hardly at all with the plate count, and fairly well with the cell count of near-aseptically drawn milk.
2. Is sensitive to the presence of cells, to the presence and activity of bacteria, and extremely so to either strong sunlight or artificial light.

It further appears that:

3. Slight variations in dye concentration exert little effect upon the readings.
4. Cooling to and holding at low temperatures definitely retards reduction.
5. Supplementary microscopic examination is advisable.
6. Especial consideration should be given the selection of a point in the range of color changes as a deadline between samples needing and not needing further inspection.
7. The resazurin test has value if properly conducted and intelligently interpreted, but it will not likely supplant the methylene blue reduction test for testing raw milk, unless the microscope and microscopist are available to afford diagnostic assistance.

J.M.F.

CHEESE

477. Alcohol-Glycerol Rennet Preparations in Cheese-Making. J. G. DAVIS, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9:* 80, 1938.

Brine rennet and alcohol-glycerol rennet extracts were compared in bacterial content, in keeping quality and in suitability for use in cheese making.

Brine rennets were found to have a bacterial count as high as 100,000 per ml., whereas the alcohol-glycerol rennets were either sterile or had a very low count. The alcohol-glycerol rennets had superior keeping qualities to the brine rennets. Chemical analysis, bacteriological analysis and graders' reports failed to distinguish the alcohol-glycerol rennet cheese from the brine rennet cheese. S.T.C.

478. **Annatto as a Cheese Colour.** M. S. Carrie, Laboratory of the New Zealand Cooperative Rennet Co., Ltd., Eltham, New Zealand. Jour. Dairy Research *9:* 72, 1938.

Standardization of annatto in aqueous solution was attacked as unsound, and it was recommended that standardization be on the basis of the depth of color produced in cheese itself. A paper color standard was suggested. S.T.C.

Other abstracts of interest are: 475, 476, 480, 481, 482, 507, 508, 509, 510, 511, 513, 514, 515, 516, 517.

CHEMISTRY

479. **A Lipase (Tributyrinase) of Cows' Milk. I. Occurrence, Method of Estimation and Relationship of Lactation Cycle.** E. C. V. Mattick and H. D. Kay, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9:* 58, 1938.

Tributyrinase in milk was estimated by determining the amount of volatile acids produced in 6 hours at 37° C. (98° F.) in a reaction mixture typically consisting of 100 ml. M/10 sodium diethyl barbiturate, 0.5 ml. pure tributyrin, and 20 ml. milk.

An enzyme which hydrolyses tributyrin was found to be present in all samples of cows' milk examined. It is associated with the aqueous rather than the fatty portion of the milk. Its optimal range of activity is in the range of pH 8.2–8.7. It is rather more thermolabile than phosphatase.

Its concentration was found to vary considerably in the milk from different cows, and during the lactation cycle in milk from individual cows. It is highest in concentration in colostrum, then the concentration falls to a minimum at about 10 days, rising later to a figure intermediate between this minimum and the colostral value. It shows no sign of increase toward the end of the lactation period. S.T.C.

480. **The Protein Distribution in Normal and Abnormal Milk.** Samuel J. Rowland, Dept. of Agric. Chemistry, University of Reading, Reading, England. Jour. Dairy Research *9:* 47, 1938.

Using the method described in the previous paper the nitrogen distri-

A study was made of a number of samples of raw and pasteurized commercial milks to determine the incidence of hemolytic streptococci and the number of kinds of species present, with an attempt to differentiate harmless types from those of possible sanitary significance. Broad-zone hemolytic types were the only ones considered. Only 8.5 per cent of the pasteurized milk samples contained hemolytic streptococci, while 18 per cent of the raw samples were positive.

On the basis of serological and physiological tests, six groups or species were recognized: *Streptococcus mastitidis* (Lancefield group B), the "animal pyogenes" (Lancefield group C), *Streptococcus durans* (Lancefield group D), and two other unidentified types.

The prevailing types of hemolytic streptococci in raw milk were found to be *Streptococcus mastitidis* and the "animal pyogenes"; the most common forms in pasteurized milk were *Streptococcus durans* and *Streptococcus zymogenes*. W.C.F.

484. Brucellosis in Horses. W. S. Stone, Experiment Station, N. Y. State Veterinary College, Ithaca, N. Y. Cornell Veterinarian *28:* p. 91, 1938.

The author reviews the literature and presents some data concerning brucellosis in horses. Agglutinins are found in apparently normal horses as well as those affected with fistulous withers and poll evil. Horses in contact with cattle have a higher incidence of brucellosis than those kept away from cattle or maintained in cities. Horses may be a factor in transmitting Bang's disease to cattle. There is evidence that undulant fever may be contracted from the discharge of brucella infected horses. J.F.

485. Detection of Mastitis by the Bromthymol-Blue Test, Leucocyte Count, and the Microscopic Examination of Incubated Milk. A. C. Fay, H. W. Cave, and F. W. Atkeson, Kansas Agricultural Experiment Station, Manhattan, Kansas. Cornell Veterinarian *28:* p. 40, 1938.

Readings of the bromthymol-blue test, the leucocyte count, and the microscopic examination of incubated milk for streptococci on repeated quarter milk samples of 114 cows are compared.

Long-chained streptococci were found in the incubated milk of 13 per cent of heifers in their first lactation period, 38 per cent of cows in their second lactation period and in increasingly high percentages in the groups in the later lactation periods. J.F.

486. Age as a Factor in Susceptibility to Johne's Disease. William A. Hagan, Department of Pathology and Bacteriology, N. Y. State Veterinary College, Ithaca, N. Y. Cornell Veterinarian *28:* p. 34, 1938.

This paper presents evidence to show that young calves are most susceptible to Johne's disease and that natural infections occur very early in life. No cases were developed naturally in the experimental herd by animals which were exposed after the fourth month of life. Even in artificial infection, using much larger doses than animals could possibly acquire naturally, no animal more than two years of age was successfully infected. The period of incubation in dosed cases runs from nine months to more than two years. Allergic tests show that many animals that have contracted the infection are able to throw it off, usually without showing any clinical evidence of the disease. J.F.

487. Bovine Mastitis. III. A Comparison of the Bacteriological and Physiological Reactions of Normal and Mastitis Milk from Young Cows. RALPH B. LITTLE, Department of Animal and Plant Pathology, The Rockefeller Institute for Medical Research, Princeton, N. J. Cornell Veterinarian *28:* p. 23, 1938.

Examinations of the foremilk of 8 first calf heifers before and after inoculation of the quarters with a double zone hemolytic streptococcus are compared. Plating of the milk in blood agar and the direct leucocyte count were found more efficient in detecting artificial infection than the hydrogen ion or chloride tests. J.F.

FOOD VALUE OF DAIRY PRODUCTS

488. Milk Important Source of a New Vitamin. ANONYMOUS. Milk Dealer *27:* 10, p. 67, July, 1938.

According to a recent study of 73 South Carolina families, pellagra did not occur in families which used on the average two and one-fourth cups of milk per person per day, plus fruits, vegetables, and lean meat. Another study of 29 Florida families revealed that the important difference in the diets of pellagrous and non-pellagrous families was in the amount of milk consumed. C.J.B.

489. The Effect of Commercial Sterilization on the Nutritive Value of Milk. S. K. KON AND K. M. HENRY, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England, with the collaboration of E. W. IKIN, National Institute for Research in Dairying, University of Reading, A. E. GILLAM, University of Manchester, Manchester, England, and P. WHITE, University of Reading, Reading, England. Jour. of Dairy Research *9:* pp. 1–29, 1938.

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483. The Hemo... NIVEN, Corn... 1938.

...ction. **S. K. Kon and K. M. Henry.**

...periments to determine the effect of sterilization on the

491. Make Merchandise Men. MALCOLM PARKS. Ice Cream Trade J. *34:* 5, p. 16, May, 1938.

The author states, "The ice cream business today is in a state of transition, retail trends are changing, new competitive threats have arisen and the emphasis is on service and co-operative effort by the dealer and company in meeting the conditions which have arisen. The dealer looks to his company to supply him with help, encouragement and ideas to combat the inroads of competition and conditions which he is unable to cope with alone. Companies are falling down on this job, largely because sheer apathy has conspired to maintain the old status quo." A Merchandising Counselors Data Chart to be used by sales managers in obtaining data on d[illegible] be used as a guide in their sales promotional work is presented. W.[illegible]

492. Who Sells Your Ice Cream for You? IRVING B. WEBER, Sidwell Dairy Company, Iowa City, Iowa. Ice Cream Trade J. *34:* 5, p. 45, May, 1938.

The per cent of ice cream sold through different types of outlets for this manufacturer is as follows:

Average Gallonage Rankings of Different Types of Accounts	My Gallonage Rankings for the Same Types
1st—Drug Stores	29% of total volume
2nd—Eating Establishments	50% of total volume
3rd—Grocery Stores	14% of total volume
4th—Filling Stations	4% of total volume
5th—Beer Parlors	2% of total volume
6th—Miscellaneous Businesses	2% of total volume

In this instance the eating establishments are out-ranking the drug stores as an outlet for ice cream. W.H.M.

493. Shrinkage—And How to Prevent It. W. B. COMBS, Dairy Division, Univ. of Minn., St. Paul, Minn. Ice Cream Trade J. *34:* 4, p. 13, April, 1938.

Factors discussed which have an effect on shrinkage in ice cream are: overrun, storage and serving temperature, composition of the mix, and size of air cells as influenced by rate of freezing and hardening. Shrinkage can be reduced in factory filled package ice cream by filling the package as quickly as possible after the ice cream comes from the freezer, placing the package immediately in the hardening room, and storing the package at a low uniform temperature. W.H.M.

494. How to Make Strawberry Ice Cream. P. H. TRACY, Dairy Dept., Univ. of Illinois, Urbana, Ill. Ice Cream Trade J. *34:* 3, p. 17, March, 1938.

Good strawberry ice cream depends on (a) a good mix, (b) the proper selection of flavoring materials, (c) the combining of the fruit with the ice cream in the proper manner, and (d) correct freezing of the ice cream.

A fresh mix free from copper contamination should be used. Only enough color to give a pinkish shade and 15 to 20 per cent of a 2.5 to 1 pack of strawberries are suggested for good results. It is important to avoid diluting the mix with fruit to a point below the legal fat standard. By adding the fruit after the ice cream is drawn from the freezer the identity of the fruit particles can be maintained. Strawberry ice cream should be sold while fresh in order to minimize the development of a stale flavor in the product. W.H.M.

495. Frozen Pack Fruits as Flavors for Ice Cream. M. A. JOSLYN AND W. C. COLE, Dairy Division, Univ. of California, Davis, Calif. Ice Cream Trade J. *34:* 3, p. 16, March, 1938.

The authors state that frozen pack fruits generally prove as satisfactory as fresh fruits for flavoring ice cream. Fruit with a pronounced flavor, and not too high in tannic acid should be used. A 2 to 1 or 3 to 1 ratio of fruit to sugar is recommended for preserving the frozen fruit for ice cream. Fifteen to 20 per cent of fruit by weight should be used in the ice cream. It is desirable to have the fruit completely defrosted before use, and fruit in smaller size is preferable to the larger size particles. Discoloration of the fruit before use tends to injure the fruit's appearance and flavor, and a high fat content mix will tend to mask the fruit flavor. W.H.M.

496. The Stabilization of Ice Cream with Sodium Alginate. V. C. STEBNITZ AND H. H. SOMMER, Dept. of Dairy Husbandry, Univ. of Wisconsin, Madison. Ice Cream Trade J. *34:* 3, p. 14, March, 1938.

Sodium alginate, "Dariloid," was subjected to various tests and compared with gelatin as a stabilizer for ice cream. Two and one-half gallon experimental mixes were made and frozen in a 10 quart vertical brine freezer. The composition of the mixes used was sugar 16 per cent, fat 13 per cent, and serum solids 10 per cent. The method recommended for adding sodium alginate was to mix it in a little cold water, and add it to the mix at 160° F.

The authors summarized their results as follows: Ice cream mix, stabilized with sodium alginate ("Dariloid") was found to possess the following properties:

1. A higher pH and lower titratable acidity than an unstabilized mix. Three-tenths per cent "Dariloid" caused an average increase of 0.15 in the pH and a decrease in the titratable acidity of 0.015 per cent.
2. Slightly more color than gelatin mixes.
3. A uniform viscosity during aging. The viscosity of the freshly made mix was practically the same as the aged mix.

4. No tendency toward wheying-off.
5. No stabilizer sediment when the sodium alginate had been properly dissolved.
6. A maximum whipping ability immediately after being homogenized and cooled to 40° F.

Ice cream made from mix stabilized with sodium alginate ("Dariloid") was found to possess the following properties:

1. A color slightly lighter than gelatin ice cream.
2. Body and texture comparable to gelatin ice cream.
3. A "cleaner" flavor than gelatin ice cream.
4. Good water-holding capacity and resistance to the effects of heat shocking.
5. No tendency toward shrinkage.
6. Smooth, clean, melt-down appearance. W.H.M.

497. Package Ice Cream. KEN FORREST, Merchandising Editor, Ice Cream Field *32* (6): pp. 7, 8, 10, June, 1938.

The author claims that unless ice cream manufacturers effectively merchandize packages and specialties, the home made dessert manufacturer "will take not only the business you hope to get, but a whole lot of business you already have."

He cites statistics from the International Association of Ice Cream Manufacturers that over 40% of the total volume sold was packages, cups and novelties.

One manufacturer is cited as successfully merchandising factory filled packages averaging only 69% overrun, in competition with cheaper merchandise.

According to the author "Your real competitor is not only your fellow ice cream manufacturer. It is the entire dessert industry, an industry that is using the power of consumer advertising to the tune of several million a year."

He emphasizes the importance of not only helping the dealer, but of using to advantage the advertising possibilities of factory filled packages.
W.C.C.

498. Liquid Sugar. L. F. DARDONE, Production Manager, B. W. Dyer & Co., Ice Cream Field *32* (6): p. 43, June, 1938.

The author states that economy in price and convenience are sufficient to justify ice cream manufacturers to use liquid sugar where available. Early supplies of liquid sugar were not well controlled technically hence their composition was not uniform or satisfactory. He states "Today it is possible to obtain liquid sugar, the solid content of which is the same composition as good granulated sugar and also with practically any invert content you may require up to completely inverted sugar." W.C.C.

499. Stale Flavor Control. K. G. WECKEL, Dairy Industry Dept., Univ. of Wisconsin. Ice Cream Field *32* (6): pp. 13, 14, 17, 36, June, 1938.

The author discusses in a very general manner some of the common problems encountered with stale flavors in ice cream. He stresses the need of controlling the quality of ingredients used and suggests the use of certain anti-oxidants (avenex and a trypsin preparation). W.C.C.

Other abstracts of interest are: 479, 480, 488, 489, 507, 508, 509, 510, 511, 513, 514 and 516.

MILK

500. **This Problem of Overlapping Ordinances.** J. W. YATES, General Laboratories, Philadelphia, Pa. Milk Dealer *27*: 9, pp. 98–101, June, 1938.

A discussion of the widespread non-uniformity in milk regulations. Examples of this non-uniformity are given. The author states that due to this non-uniformity much good milk is being rejected and does not have a free market, while other milk of inferior quality, in some instances, is permitted to be sold. C.J.B.

501. **Soft Curd Milk.** ANONYMOUS. Milk Dealer *27*: 9, pp. 62–66, June, 1938.

A review of the research work which has been done by the dairy schools on soft-curd milk. C.J.B.

502. **Homogenized Milk.** ANONYMOUS. Milk Dealer *27*: 9, pp. 37, 58, June, 1938.

Further reports on what dealers who distribute homogenized milk think of the product. These dealers report a steady increase in homogenized milk sales. Some of them also report increased sales of cream due to the sale of homogenized milk. C.J.B.

503. **Detecting Under Pasteurization by Means of the Phosphatase Test.** DR. T. H. BUTTERWORTH, Dept. of Health, San Antonio, Tex. Milk Dealer *27*: 9, pp. 33, 66–70, June, 1938.

A brief description of the phosphatase test and how it is of value to the milk-plant operator as well as to the control official. C.J.B.

504. **Da-Lite Dairy.** ANONYMOUS. Milk Dealer *27*: 8, pp. 46, 47, 67, May, 1938.

A brief description of the Holbrook Farms Dairy at Brentwood, Maryland. C.J.B.

505. **Efficiency and Sanitation.** ANONYMOUS. Milk Dealer *27*: 8, pp. 44, 45, 82, May, 1938.

A description of Moore Brothers' Dairy at Ames, Iowa. C.J.B.

506. Homogenized Milk. ANONYMOUS. Milk Dealer *27*: 8, pp. 38, 39, 69, May, 1938.

The usual response to a questionnaire sent to milk distributors from Virginia to the State of Washington, and from Canada to Tennessee, was to the effect that "once customers use homogenized milk they like it very much and don't change back to regular milk," or from month to month its popularity to date has been increased.

The type of outlet of homogenized milk and the reaction of individual distributors to the product are also given. C.J.B.

Editor's Note:—This article is based on the response of 15 milk distributors who have been distributing homogenized milk from 1 month to 10 years. These distributors were contacted by The Milk Dealer to learn the favor accorded this product.

Other abstracts of interest are: 474, 475, 476, 479, 480, 481, 482, 483, 485, 487, 488, 489, 507, 508, 509, 510, 511, 512, 513, 514 and 516.

MISCELLANEOUS

507. Minimum Wage Legislation. BERNARD SUMMER, Ice Cream Trade J. *34*: 4, p. 24, April, 1938.

The author presents the fourth of a series of tables showing violations and penalties, by states, as outlined in the Minimum Wage Legislation. W.H.M.

508. Showmanship in Business. ZENN KAUFMAN. Ice Cream Field *32* (6): p. 23, June, 1938.

This is a concluding article of a series by the author. He states "Keep your advertising simple by emphasizing one basic appeal possessed by your product. You may want to stress purity, economy, flavor, healthfulness, or reputation. All these factors have their merits but when thrown on the public all in a heap their effectiveness is lost." W.C.C.

509. Social Security. J. S. SEIDMAN, C.P.A., Director, New York Chapter, National Association of Cost Accountants. *Milk Dealer 27*: 10, p. 60, July, 1938.

A brief discussion of the link between payroll taxes and income taxes formed by a recent decision which allows employers to deduct payroll taxes on their Federal income tax returns. C.J.B.

510. Microbe "Death Ray" Lamp. ANONYMOUS. Milk Dealer *27*: 10, pp. 36–37, July, 1938.

An ultra-violet lamp, developed by Drs. Rentschler and James, is reported to give 99.99 per cent sterilization in a few seconds time. C.J.B.

511. A New Light Weight Stainless Steel. ANONYMOUS. Milk Dealer *27:* 10, p. 33, July, 1938.

Ludlite, a new stainless steel, consists of a Silcrome stainless steel facing approximately 0.0095 inch thick, with a tough, waterproof, flexible backing of non-metallic material. The Silcrome stainless steel and the flexible backing are permanently combined under heat and pressure.

Ludlite has already been used as a building material in many ways. Its flexibility and relatively low cost opens almost unlimited possibilities for use in the bottled milk industry. C.J.B.

512. A Cornhusker Sees European Dairying. PROF. H. P. DAVIS, Dairy Husbandry Department, Univ. of Nebr. Milk Dealer *27:* 9, pp. 76–79, June, 1938.

The author describes the dairy industry of Europe. C.J.B.

513. Highlights of the New Tax Law. J. L. SEIDMAN, C.P.A., Director, New York Chapter, National Association of Cost Accountants. Milk Dealer *27:* 9, pp. 42, 66–67, June, 1938.

The author discusses the effect of the new tax law on corporations and individuals. Income tax rates, capital gains and losses, and other provisions of the new law are discussed. C.J.B.

514. Some Practical Suggestions on Fighting Flies. ANONYMOUS. Milk Dealer *27:* 8, pp. 74–76, May, 1938.

Practical method of preventing the access of flies into the milk plant and methods of disposing of those which get into the plant are given. C.J.B.

515. Lanital, the New Textile Material Made from Casein. ANONYMOUS. Milk Dealer *27:* 8, p. 72, May, 1938.

A brief description of the process and present status of obtaining a spinning fibre from casein. C.J.B.

516. The Need for Scientific Cleaning and Sterilization of Dairy Equipment. W. E. NOYES, The Diversey Corporation, Chicago, Ill. Milk Dealer *27:* 8, pp. 52–60, May, 1938.

The author gives a full discussion of the following points:

1. The fundamental factors to consider in analyzing the cleaning job.
2. The factors to consider in selecting a cleaning compound.

3. Properties which a cleaner for general use in the plant should have.
4. Points to check in the operation of the can washer.
5. Properties to consider in selecting a washing product to use in the bottle washer.
6. Properties to consider in selecting a sterilizer for use on the dairy farm and in the milk plant.
7. Methods of using chemical sterilizers. C.J.B.

517. Preparation of Cultures. JOSEPH BURNS, Mgr., Capitol Dairy, Madison, Wis. Milk Dealer *27:* 8, pp. 49, 78, May, 1938.

A description of the preparation and control of cultures. The author gives the following 4 laws of culture control:

1. Use good mother culture.
2. Sterilize all utensils and containers before and during process of manufacture.
3. Use clean base for medium. The skim or whole milk used must be fresh.
4. Have proper and uniform incubating temperature, together with correct length of time. C.J.B.

PHYSIOLOGY

518. Intervals in the Electrocardiograms of Calves Fed Cod Liver Oil. LEROY L. BARNES, GEORGE K. DAVIS, AND C. M. MCCAY, Laboratory of Animal Nutrition, Cornell University, Ithaca, N. Y. Cornell Veterinarian *28:* p. 16, 1938.

The feeding of various levels of cod liver oil did not affect the intervals in the electrocardiograms of calves. There was a gradual increase in the intervals, most prominent in the P.R. intervals, as the animals grew older. Histological studies of the hearts revealed no lesions. J.F.

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JOURNAL OF DAIRY SCIENCE

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JOURNAL OF DAIRY SCIENCE

VOLUME XXI NOVEMBER, 1938 NUMBER 11

EFFECT OF SHAKING ON THE LIPOLYSIS OF COW'S MILK[1]

V. N. KRUKOVSKY AND PAUL F. SHARP

Department of Dairy Industry, Cornell University, Ithaca, New York

INTRODUCTION

Eufinger (10) showed that the titratable acidity of human milk increased several fold as a result of shaking for a few hours, and that the increase was associated with the presence of fat since the acidity did not increase when skimmilk was shaken. He found further that the increase in acidity was slight when cow's milk was shaken, and concluded that this difference could be used to distinguish between cow's and human milk. Engel (8, 9) was loath to accept the idea that the increase was the result of lipase action, because usually enzymes are inactivated by shaking. Davidsohn (5), Behrendt (2, 3), Schlossmann (19), and Freudenberg (11) concluded that shaking activated the enzyme or cleared the surface of the fat globules for action. A difference in the effect of shaking on the increase in acidity of cow's and human milk was noted by Eufinger (10), Davidsohn (5) and Behrendt (2), and the two last named investigators observed a marked alteration in surface tension as a result of shaking human milk. Krukovsky and Sharp (14) found a marked increase in titratable acidity due to lipolysis during the churning of raw cream separated from the milk of certain cows in advanced lactation. This result indicated that the lipase of cow's milk could be activated by shaking, and that shaking could be used as a method for activating and studying the true lipase of milk. Some of the results obtained are presented in this paper.

Paraschtschuck (18), Eckles and Shaw (7), Palmer (17), Sharp and de Tomasi (20), Csiszár (4), Hileman and Courtney (13), Anderson (1), Krukovsky and Sharp (14) and others have shown the marked lipolytic activity of milk from certain cows, particularly those in advanced lactation.

Most of these investigators are of the opinion that some other factor in addition to advanced lactation is necessary for the production of milk in which the lipase is naturally active. This contributing factor may be temperature, season, feed, or some other factor affecting the physiology of milk secretion or its composition.

Received for publication May 4, 1938.

[1] We are indebted to the Joseph Willmann Dairy Research Fund for a grant in aid of this investigation.

EXPERIMENTAL

The method consisted in the determination of the increase in titratable acidity expressed as percentage lactic acid and decrease in pH which resulted from shaking 25 ml. of milk in 75 ml. test tubes. The tubes were shaken violently in a motor-driven machine which was placed in a room of constant temperature.

Table 1 shows that samples of raw milk from different cows decreased an average of 0.30 pH when shaken for 2 hours at 37° C.; whereas pasteurized aliquots shaken, raw milk held for 2 hours at 37° C. without shaking, or held over night at 5° C., showed no change in pH.

TABLE 1

Effect of 2 hours' shaking at 37° C. on the pH of raw and pasteurized whole milk

Sample number	Fresh raw pH	Over night at 5° C. raw pH	2 hours at 37° C.			
			Raw held unshaken pH	Shaken 2 hours		
				Past. pH	Raw pH	Dif. pH
1	6.52	6.53	6.50	6.52	6.22	0.30
2	6.64	6.66	6.64	6.66	6.41	0.25
3	6.63	6.66	6.62	6.63	6.35	0.28
4	6.53	6.55	6.48	6.55	6.16	0.39
5	6.55	6.56	6.54	6.55	6.27	0.28
6	6.62	6.63	6.60	6.62	6.28	0.34
7	6.61	6.52	6.42	6.52	6.22	0.30
8	6.65	6.56	6.51	6.60	6.23	0.37
9	6.49	6.52	6.50	6.49	6.35	0.14
10	6.56	6.60	6.57	6.57	6.22	0.35
Average	6.58	6.58	6.54	6.57	6.27	0.30

Experiments of a similar type in which the milk was shaken for 2 hours at 25° C. with and without the addition of ethyl butyrate are presented in Table 2. The first group of samples were from cows in the middle of the lactation period, the second group from cows at the end of the lactation period. The experiments were run during November and December of 1935. The samples from the group of cows in the more advanced period of lactation did not show greater lipolytic activity as a result of shaking. The increase in acidity as a result of shaking was slightly greater in the presence of ethyl butyrate, which was added originally because it usually prevents churning. The increases in titratable acidity parallel the decreases in pH. The acidity increased less with shaking at 25° C. than at 37° C.

TABLE 2

Effect of 2 hours' shaking at 25° C. on the increase in acidity of raw and pasteurized milk

Sample Nos. 1 to 10 from cows relatively high in milk production

Sample Nos. 11 to 20 from cows relatively low in milk production

Sample number	pH						Acidity as % lactic acid					
	Natural whole milk			Natural whole milk + 2% ethyl but.			Natural whole milk			Natural whole milk + 2% ethyl but.		
	Raw	Past.	Dif.	Raw	Past.	Dif.	Raw	Past.	Dif.	Raw	Past.	Dif.
	pH	*pH*	*pH*	*pH*	*pH*	*pH*	%	%	%	%	%	%
1	6.25	6.54	0.29	6.18	6.57	0.39	.227	.170	.057	.245	.166	.079
2	6.29	6.54	0.25	6.17	6.54	0.37	.220	.175	.045	.230	.175	.055
3	6.28	6.47	0.19	6.21	6.45	0.24	.225	.185	.040	.235	.187	.048
4	6.40	6.64	0.24	6.22	6.62	0.40	.172	.120	.052	.202	.125	.077
5	6.21	6.62	0.41	6.13	6.61	0.48	.260	.160	.100	.270	.155	.115
6	6.20	6.49	0.29	6.11	6.49	0.38	.262	.185	.077	.292	.187	.105
7	6.32	6.43	0.11	6.26	6.43	0.17	.217	.190	.027	.222	.190	.032
8	6.26	6.53	0.27	6.08	6.49	0.41	.235	.175	.060	.265	.180	.085
9	6.25	6.41	0.16	5.99	6.40	0.41	.225	.197	.028	.250	.195	.055
10	6.37	6.53	0.16	6.20	6.53	0.33	.220	.175	.045	.240	.175	.065
Average	6.28	6.52	0.24	6.16	6.51	0.36	.226	.173	.053	.245	.174	.071
11	6.32	6.62	0.30	6.28	6.58	0.30	.190	.132	.058	.195	.137	.058
12	6.47	6.66	0.19	6.40	6.65	0.25	.195	.155	.040	.205	.155	.050
13	6.33	6.65	0.32	6.26	6.64	0.38	.185	.125	.060	.200	.130	.070
14	6.45	6.82	0.37	6.40	6.82	0.42	.180	.110	.070	.190	.110	.080
15	6.62	6.80	0.18	6.60	6.80	0.20	.175	.130	.045	.175	.130	.045
16	6.36	6.63	0.27	6.26	6.63	0.37	.200	.125	.075	.227	.125	.102
17	6.51	6.68	0.17	6.56	6.72	0.16	.180	.137	.043	.180	.137	.043
18	6.38	6.67	0.29	6.31	6.67	0.36	.197	.130	.067	.210	.132	.078
19	6.58	6.81	0.23	6.58	6.82	0.24	.157	.117	.040	.160	.120	.040
20	6.29	6.52	0.23	6.26	6.50	0.24	.225	.165	.060	.240	.170	.070
Average	6.43	6.68	0.25	6.39	6.68	0.29	.188	.133	.055	.198	.134	.064

Table 3 shows that the acidity increases with time of shaking, the greatest increase occurring in the first two hours. After a preliminary shaking at 25° C., the acidity continues to increase even when the milk is held afterward at 2° C. The relative increases are much the same when 2 per cent tributyrin is added, but the actual increases in acidity are greater, and the unshaken samples containing tributyrin show a marked increase in acidity on holding. Table 3 shows that milk which normally shows no lipolytic activity is capable of activation to produce definite lipolysis.

Temperature is a controlling factor in lipolytic activation of milk by shaking. If the milk is held and shaken at low temperatures the lipase is not activated. Table 4 shows a comparison of milk shaken at 2° and at 25° C. Definite lipolysis of natural fat occurred in the case of only one sample which was shaken and held at 2° C. This sample was undoubtedly one of those in which the lipase was naturally active. Since shaking is not

TABLE 3

Effect of time of shaking at 25° C. and time of subsequent holding at 2° C. on the increase in titratable acidity and decrease in pH of raw milk

Time of holding at 2° C. after shaking, hours	Control	Natural raw whole milk						Raw whole milk + 2% tributyrin					
		Hours of shaking at 25° C. prior to holding at 2° C.						Hours of shaking at 25° C. prior to holding at 2° C.					
		0	½	1	2	3	4	0	½	1	2	3	4
		Increase in titratable acidity, per cent											
0	.001	.005	.013	.022	.038	.049	.055	.017	.037	.041	.078	.097	.106
24	.001	.018	.042	.049	.069	.067	.085	.063	.132	.126	.147	.154	.161
48	.001	.029	.059	.069	.084	.089	.094	.105	.174	.171	.189	.175	.187
72	.005	.041	.075	.082	.092	.102	.109	.125	.204	.206	.222	.209	.219
		Decrease in pH											
0	.02	.00	.07	.10	.16	.17	.21	.14	.42	.42	.57	.61	.67
24	.07	.06	.19	.20	.29	.30	.32	.43	.71	.67	.77	.75	.77
48	.05	.11	.23	.26	.32	.32	.36	.56	.78	.84	.86	.87	.88
72	.03	.19	.27	.32	.35	.41	.41	.63	.88	.87	.96	.93	.93

necessary to induce the hydrolysis by raw milk of simple esters such as tributyrin and ethyl butyrate, the samples to which the esters were added and which were shaken and held at 2° C. showed appreciable hydrolysis when held for 24 hours.

Most of the experiments on lipolysis due to shaking, previously reported in the literature, had been performed with human milk. Table 5 shows that little lipolysis of human milk occurs as a result of shaking at a low

TABLE 4

Effect of holding for 24 hours at 2° C. on the increase in titratable acidity after shaking for 2 hours at 25° and 2° C. Milk from cows late in lactation

	Cow number				
	1	2	3	4	5
Direct titratable chloride value, per cent	.137	.129	.178	.143	.152
Titratable acidity, unshaken sample, per cent	.175	.160	.092	.165	.140
pH	6.59	6.52	6.86	6.52	6.64
	Increase in titratable acidity				
Natural raw milk shaken 2 hrs. at 25° C.	.055	.030	.035	.047	.047
Shaken 2 hrs. at 25° C. and held 24 hrs. at 2° C.	.090	.058	.052	.072	.078
Raw milk + 2% ethyl butyrate shaken 2 hrs. at 25° C.	.055	.060	.040	.053	.063
Shaken 2 hrs. at 25° C. and held 24 hrs. at 2° C.	.113	.110	.070	.105	.125
Natural raw milk shaken 2 hrs. at 2° C.	.000	.000	.010	.002	.022
Shaken 2 hrs. at 2° C. and held 24 hrs. at 2° C.	.000	.018	.007	.010	.038
Raw milk + 2% ethyl butyrate shaken 2 hrs. at 2° C.	.020	.015	.015	.010	.020
Shaken 2 hrs. at 2° C. and held 24 hrs. at 2° C.	.100	.105	.050	.080	.085

pH determinations were also made. They confirm the results of the titratable acidity values.

TABLE 5

Effect of temperature of shaking on the lipolysis of human milk as indicated by the increase in titratable acidity expressed as lactic acid

Time of experiment, 1 hour	Temperature 5–6° C.	Temperature 25–28° C.
	Titratable acidity per cent	
Unshaken	.023	.023
Shaken	.027	.108
Shaken	.032	.108

temperature, as contrasted with shaking at 25° C. These results confirm previous investigations indicating that lipolysis of human milk is stimulated to a greater extent by shaking than is lipolysis of cow's milk.

Anderson (1) and Mattick and Kay (16) used tributyrin as a substrate for studying the lipolytic activity of cow's milk. Experiments indicate that shaking is not necessary to induce hydrolysis of simple esters. The fact that no activation is necessary to cause the hydrolysis of simple esters, whereas activation is necessary to induce the true lipolysis of the natural fat, serves to differentiate the two reactions. The hydrolysis caused by

TABLE 6

Effect of the combination of ethyl butyrate and tributyrin on the increase in titratable acidity and decrease in pH. Shaken (2 hours at 25° C.) and unshaken milk after holding at 2° C. for 24 hours

	Increase in titratable acidity: Shaken %	Increase in titratable acidity: Unshaken %	Decrease in pH: Shaken pH	Decrease in pH: Unshaken pH
	Sample No. 1 0.118% apparent titratable Cl			
Natural raw milk	.095	.005	.34	.00
Raw milk + 2% ethyl-n-butyrate	.142	.115	.64	.51
Raw milk + 2% tributyrin	.168	.127	.88	.67
Raw milk + {1% ethyl-n-butyrate, 1% tributyrin}	.142	.122	.75	.64
Raw milk + {2% ethyl-n-butyrate, 2% tributyrin}	.155	.137	.81	.73
	Sample No. 2 0.178% apparent titratable Cl			
Natural raw milk	.050	.007	.32	.05
Raw milk + 2% ethyl-n-butyrate	.065	.067	.36	.36
Raw milk + 2% tributyrin	.100	.070	.62	.49
Raw milk + {1% ethyl-n-butyrate, 1% tributyrin}	.095	.073	.67	.54
Raw milk + {2% ethyl-n-butyrate, 2% tributyrin}	.095	.075	.67	.54

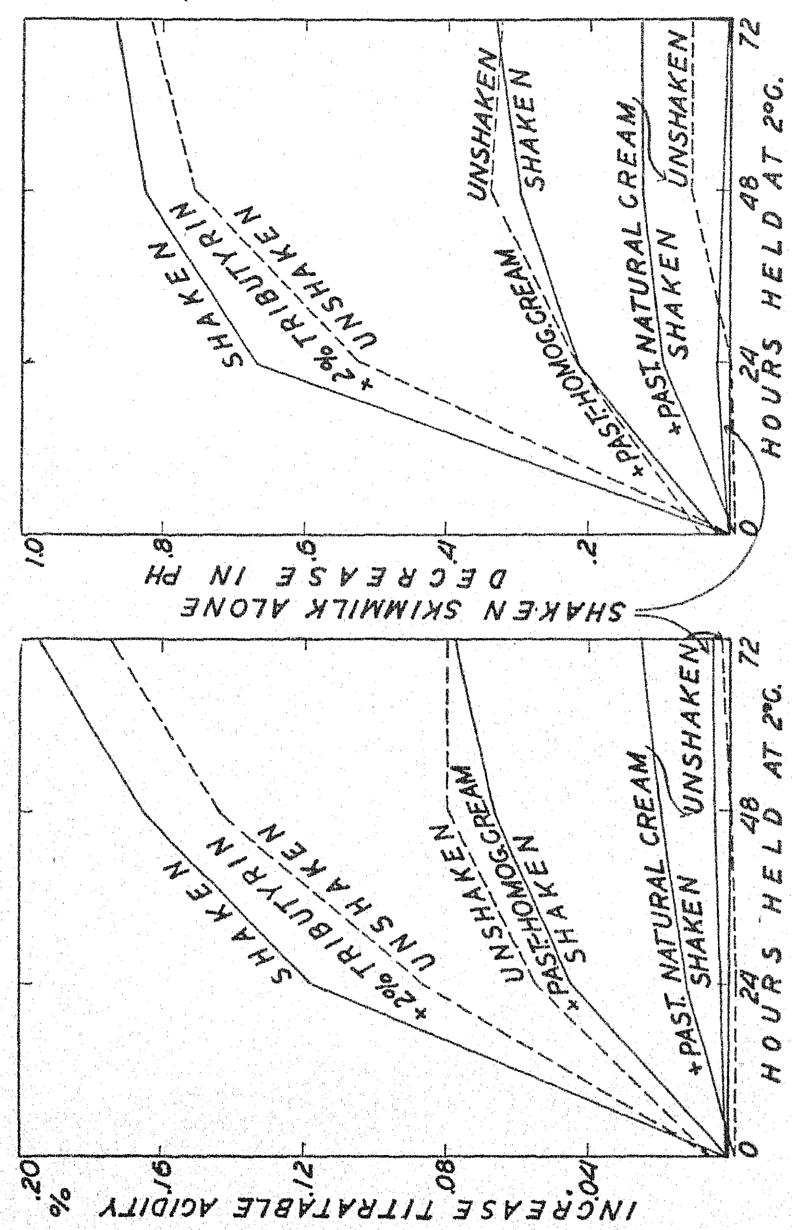


Fig. 1. Effect on lipolytic activity of reconstituting shaken and unshaken skimmilk with homogenized and natural cream and the addition of tributyrin.

shaking milk to which the simple esters were added was greater than that of the milk when shaken alone, but the increase in acidity was not the sum of the two processes operating alone. Table 6 presents further evidence that the increases in acidity produced by shaking milk alone and when both tributyrin and ethyl butyrate are present is not additive. The increase in acidity seems to approach a limiting value, indicating the establishment of an equilibrium or the retardation of the action of the enzyme due to the low pH.

As indicated in Figure 1, little subsequent effect of the shaking was found when 2% tributyrin, 4% homogenized cream, or 4% natural cream was added to shaken and unshaken skimmilk. Marked lipolysis occurred when pasteurized homogenized cream was added to raw skimmilk, but not when pasteurized natural cream was added.

No important influence of breed on the increase in acidity as a result of shaking was found, as shown by Table 7, although the milk from Jersey cows showed slightly greater increases in acidity.

TABLE 7

Effect of breed on the increase in acidity produced by shaking for 2 hours at 25° C.

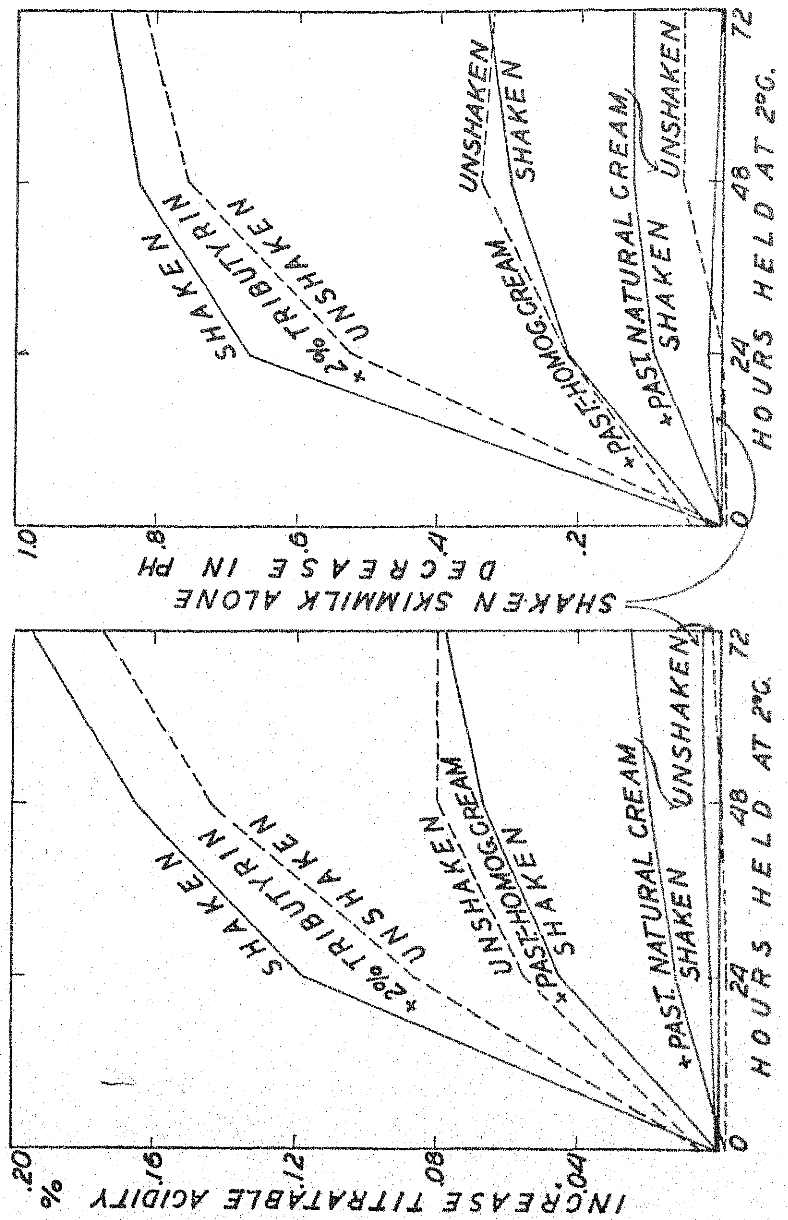
	Decrease in pH		Increase in titratable acidity	
	Natural milk	Natural milk + 2% ethyl butyrate	Natural milk	Natural milk + 2% ethyl butyrate
	pH	*pH*	%	%
Holstein	.23	.31	.049	.059
Jersey	.25	.31	.067	.076
Guernsey	.23	.33	.048	.061
Ayrshire	.23	.30	.052	.064
Average	.24	.31	.054	.065

A definite relation exists between the increase in titratable acidity and the decrease in pH, as shown in Figure 2, but since with the same increase in titratable acidity different alterations in pH would occur because of the difference in the buffer value of the milk, the increase in titratable acidity would be more directly related to the lipase activity.

The increase in titratable acidity as a result of shaking the natural milk for 2 hours at 25° C., although less, is in general linearly related to the increase if ethyl butyrate or tributyrin is added, as shown in Figure 3.

No relation between the amount of milk produced per day and the increase in titratable acidity resulting from shaking is shown in Figure 4.

The milk from a large number of cows was tested to see if the lipase was naturally active. The milk was cooled at once and held cold for 2 days.



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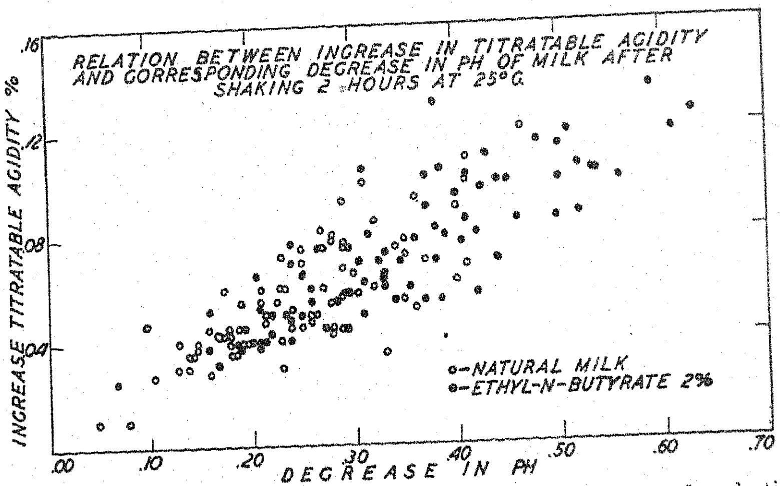

FIG. 2. Relation between the increase in titratable acidity expressed as lactic acid and the decrease in pH as a result of shaking.

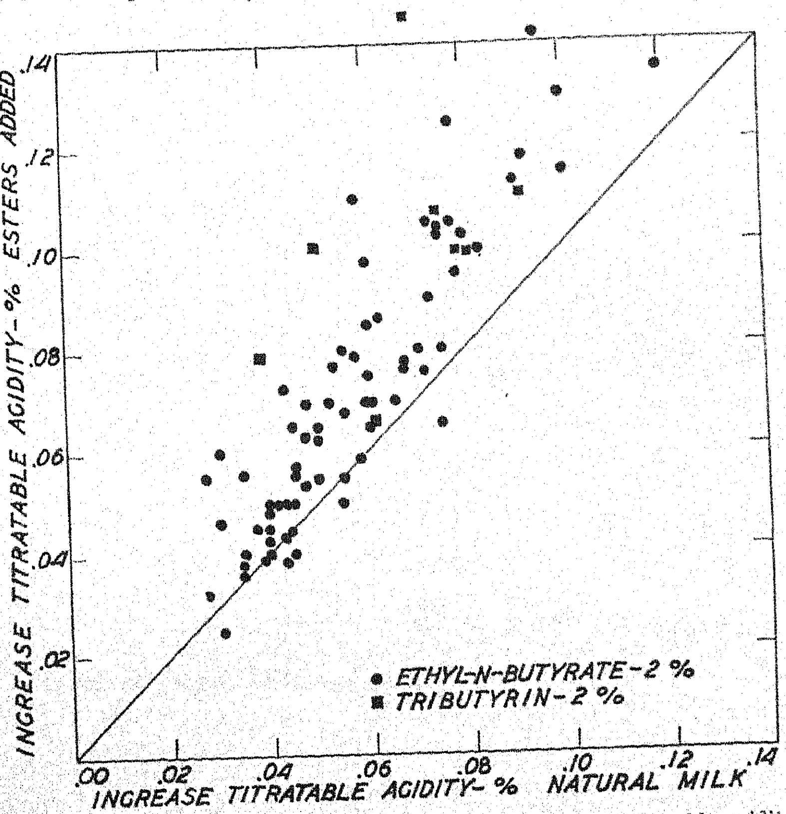

FIG. 3. Effect of the addition of esters on the increase in titratable acidity produced by shaking milk for 2 hours at 25° C.

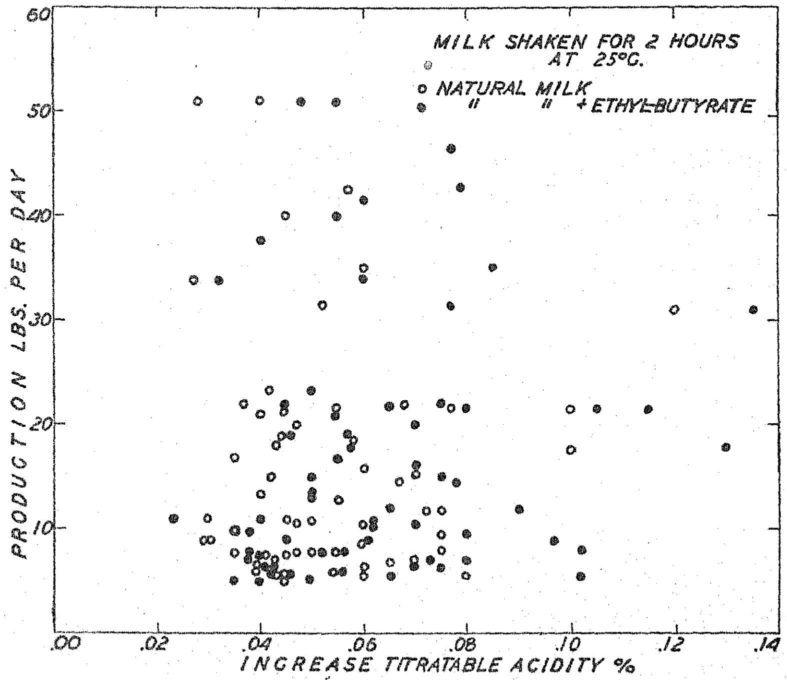

FIG. 4. Relation between the production of milk in pounds per day and the increase in titratable acidity produced by shaking.

An increase in titratable acidity on holding was taken as an indication that the lipase was naturally active. The milk from a large number of cows in advanced lactation in the summer was tested, but none showed an increase in titratable acidity. A few cows in advanced lactation in winter

TABLE 8

Milk obtained in the winter which showed natural lypolytic activity

Cow No.	Increase in titratable acidity as a result of		Direct titratable chloride value	Month of lactation	Milk per day
	Holding unshaken at 2° C. for 48 hrs.	Shaking 2 hrs. at 25° C.			
	%	%	%		*lbs.*
1 Jersey	0.020	0.053	0.09	10	7.7
2 Jersey	0.024	0.055	0.12	11	7.0
3 Holstein	0.028	0.025	0.15	11	9.0
4 Holstein	0.055	0.055	0.15	12	2.2
5 Holstein	0.038*	0.047	0.15	......	10.6

* Held cold 24 hours.

gave milk in which the acidity increased on holding. The data are presented in Table 8. Although this milk was naturally lipolytically active, it showed about the same lipolyis as a result of shaking as did average normal milk.

DISCUSSION

Shaking raw milk while the fat is in the liquid or partially liquefied state activates the lipase naturally present. Hydrolysis of the fat is indicated by the increase in titratable acidity, decrease in pH, and the characteristic odor and taste of the milk. Although shaking apparently gives no indication as to whether the lipase is naturally active in the milk, it does afford a simple method of demonstrating quickly the lipolytic potentialities of the milk.

Dorner and Widmer (6) found that the lipase of raw milk could be activated by homogenization. This fact has been confirmed by others (20), and Gould and Trout (12) showed that tremendous increases in the acidity of the fat occurred. Van Dam (21) has shown that the degree of dispersion of the fat is increased by shaking milk while the fat is in the liquid state. We have confirmed this observation. Thus activation of lipase by homogenization and by shaking may be basically the same. Whether an increase in degree of dispersion is necessary in order to activate the lipase of the milk by shaking, or whether the activating mechanism is an alteration in the surface characteristics of the fat globules, is not clearly demonstrated by the shaking experiments alone. The alteration in the surface characteristics is believed to be the activating factor, the increase in the degree of dispersion being largely incidental. This belief is strengthened by the known influence of temperature of separation on the lipolytic activity of cream (20). Cream from milk, warmed and separated while the fat is in the liquid state, shows little lipolytic activity as contrasted to cream separated while the fat is in the solid or partially solid state. Both creams show about the same amount of lipolytic activity when subsequently activated by homogenization. This indicates that lipase is actually present in both creams, but because of the previous temperature history of the fat and its physical state, in one case the lipase is active, in the other not.

Lundstedt (15) claimed that whipping cold milk lowered the curd tension of the milk. He attributed this lowering of the curd tension to materials removed from the surface of the fat globules as a result of the agitation. In our experiments, shaking cold raw milk did not induce lipolysis of cow's milk nor of human milk.

Under certain conditions raw milk from some cows in advanced lactation naturally shows lipolysis when held cold for a day or two. It is but natural to draw the conclusion that such milk contains more lipase than does other more normal milk which does not increase in acidity under the same conditions. However, when both types of milk are subjected to

special activating treatments such as to shaking or homogenization, they both show about the same amount of lipolytic activity. These results point to the conclusion that, although the amount of lipase as evidenced by shaking may vary considerably, yet all milk contains enough lipase which if activated would produce rancid milk, but only in the case of certain cows, usually in advanced lactation, is the condition of the milk such that when cooled at once the lipase is in a naturally activated state. We use the term activation in a broad sense to include the possibility that the apparent activation may be due to the prevention of the action of an inactivator.

CONCLUSIONS

1. Shaking of raw, whole cow's milk, while the fat is in the liquid or partially liquefied state, induces lipolysis.
2. Lipolysis induced by shaking will continue after the milk has been cooled to low temperatures.
3. The amount of lipolysis induced by shaking bears little or no relation to breed, season, or milk production of the cow.
4. The effect of shaking is attributed to an alteration in the surface characteristics of the fat globules which creates a condition more favorable for lipolysis.
5. Apparently all milk is capable of appreciable true lipolytic activity if subjected to suitable activating treatments, but only from some cows, particularly those in advanced lactation in winter, is milk secreted which when cooled and held will show natural lipolytic activity.

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VOLUME CHANGES OF FAT IN COOLED CREAM HELD AT CONSTANT TEMPERATURE

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INTRODUCTION

The increase in the specific gravity of milk when held cold at a constant temperature has been observed by Schröder (4), Toyonaga (6), and many others (2). Toyonaga explained the increase as due to the solidification of the fat. Attention has recently been called to the influence of the physical state of the fat on the specific gravity determination (5). The evidence is clear that a shrinkage in volume occurs at constant temperature when milk or cream is cooled quickly and held at temperatures which induce fat crystallization. Because of the much greater lag in phase change of fat globules, the time required for fat in mass to crystallize gives little information as to the time required for fat globules in milk or cream to crystallize. A study of the change in physical state of the fat as indicated by specific heat determinations indicated that about 4 hours were required for the physical state to approximate the equilibrium value (3). In the present study, dilatometers were used to follow the change in physical state of the fat at constant temperature.

The dilatometer has previously been used principally to measure the expansion of the fat in cream, on warming after having been subjected to different degrees of cooling. Van Dam (8, 9) found that the maximum expansion occurred between 12 and 18° C. Hansen and Jensen (1) also showed that the more the cream was cooled the greater the expansion of the fat on warming.

EXPERIMENTAL

The construction of the dilatometer used is illustrated in Figure 1. The bore of the stopcock was large enough to permit the insertion of a drawn out glass tube through which the cream was introduced. This permitted the escape of the air and the complete filling of the bulb. The bulbs held 35 to 40 ml. The distance between the level of the mercury in the side arm capillary and a reference mark on the capillary was determined by means of a cathetometer. The diameter of the capillary side arm was previously determined by measuring the length of a mercury thread and weighing the mercury. From the movement of the mercury due to contraction of the fat, the contraction in volume per 100 grams of fat was calculated.

Received for publication May 4, 1938.

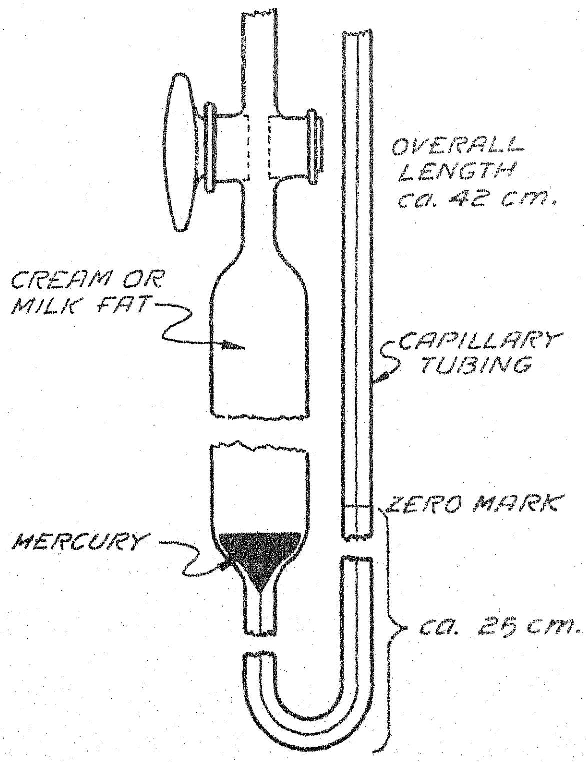

FIG. 1. Dilatometer used to measure the change of volume of fat in cream.

Several hours before beginning the experiment, the weighed dilatometers were placed in water baths maintained at the desired temperature by being held in thermostatically controlled air ovens which in turn were placed in refrigerated rooms. Cream from mixed milk was heated to 80° C. for 10 minutes, and cooled to 40° C., when 0.5 per cent of mercuric chloride was added (7). The cream was then filtered through cotton and stored at near freezing. Before being placed in the dilatometer the cream was warmed to 45° C. to melt the fat in the globules. It was then cooled to the temperature of the water bath, and the dilatometer was filled.

The dilatometers were held for five months at constant temperatures ranging from 0 to 20° C. The contraction in cc. per 100 grams of fat during the first 48 hours is plotted in Figure 2. The decrease in volume of the fat occurred rapidly at 0, 5, and 10° C. after adjusting the cream to the temperature of the bath; the contraction took place more slowly at 15° C. and very slowly at 20° C. Some contraction occurred at the lower temperatures before the cream could be cooled, adjusted to the temperature of the bath, the tonometer filled and the first reading taken. Therefore the data presented in Figure 2 should not be taken as an accurate indication

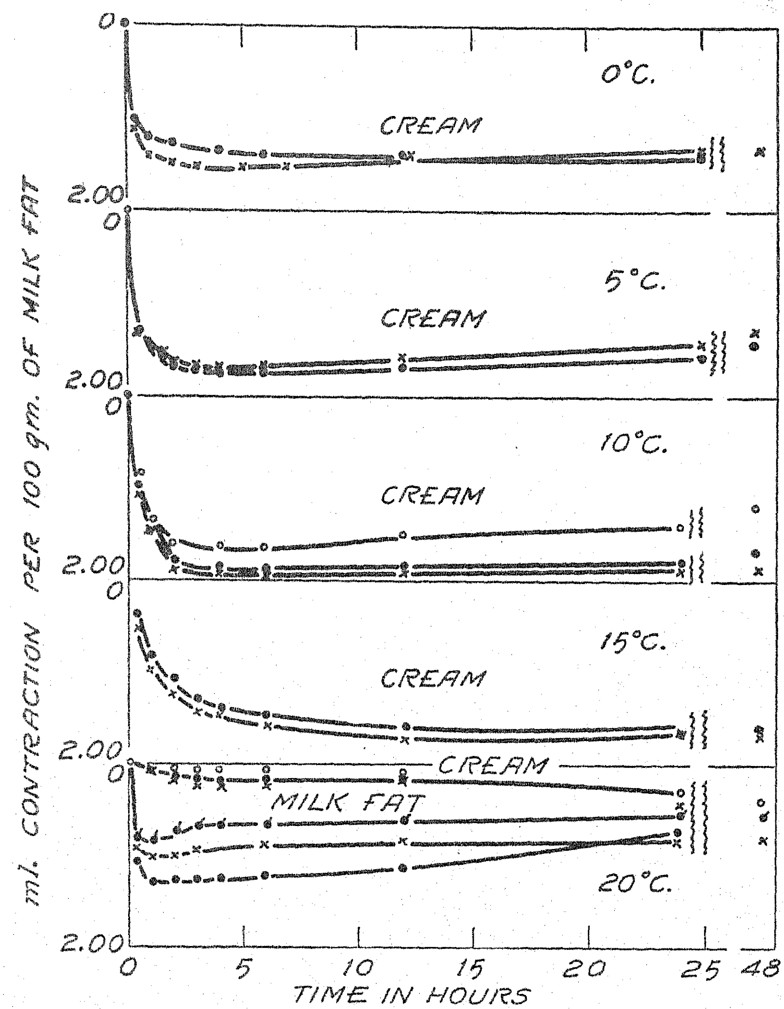

FIG. 2. Change in volume of milk fat in cream and in mass when held at constant temperature. Calculated on the basis of cc. change in volume per 100 grams of fat.

of the total contraction which occurred at the lower temperatures. The curves indicate the rate of contraction as influenced by temperature. At temperatures below 10° C., after the very rapid decrease in volume a slow increase in volume occurred. The increase occurred over a period of months, as is shown more clearly in Table I. At the present time the explanation for this slow expansion is not clear, but it is probably due to some slow phase adjustment following the relatively rapid original crystallization of the fat. The secondary expansion was not observed in cream held at 15 and 20° C., but it was observed in pure fat held at 20° C. The decrease in volume of the fat in cream held at 25° C. occurred so slowly

TABLE I

Decrease in volume of fat on holding cream and pure milk fat for various periods of time at constant temperature

Temperature of holding	cc. decrease in volume per 100 grams of milk fat after							
	30 min.	1 hour	4 hrs.	1 day	1 week	1 mo.	2 mo.	5 mo.
° C.				40% fat cream				
0	1.01	1.23	1.36	1.38	1.30	1.08	0.95	......
	1.14	1.41	1.55	1.39	1.28	1.15	1.16	1.12
5	1.32	1.48	1.75	1.60	1.20	1.09	1.12	1.25
	1.30	1.46	1.71	1.49	1.12	.92	.81	.99
10	1.05	1.46	1.84	1.81	1.69	1.68	1.68	1.57
	1.08	1.48	1.90	1.92	1.92	1.94	1.92	2.07
	0.89	1.31	1.60	1.38	1.13	1.24	1.37	1.76
15	0.41	0.82	1.35	1.54	1.65	1.71	1.67	1.97
	0.52	0.98	1.49	1.68	1.72	1.71	1.75	2.29
	0.37	0.84	1.34	1.54	1.68	1.78	1.87	2.35
20	0.00	0.06	0.19	0.28	0.29	0.40	0.59	1.52
	0.00	0.12	0.27	0.40	0.44	0.54	0.81	1.34
	0.00	0.03	0.17	0.29	0.32	0.40	0.76	1.33
				Pure milk fat				
20	0.96	1.05	0.85	0.77	0.77	0.74	0.68	0.80
	0.85	0.80	0.67	0.63	0.59	......	0.41	0.31
	1.03	1.30	1.27	0.70	0.60	......	0.48	0.39

that dilatometers were not held at this temperature. The changes in volume of the fat in cream held for the longer periods of time are given in Table I.

Table I shows that it may require weeks or months for the fat to attain a state of equilibrium when held at constant temperatures of 20° C. or below. This table emphasizes again the unsuitability of temperatures at which the fat may be in the crystalline state, for obtaining the specific gravity values which are used for the calculation of total solids (5).

Although Figure 2 and the specific heat values previously reported (3) indicate that within 4 hours phase adjustment of the fat approaches a relatively stable state, yet Table I shows that superimposed on this apparently stable state is a secondary adjustment which may require months. In Table I the data for 10° C. are not consistent. This temperature is probably near the point at which the two behaviors are occurring simultaneously at near the same rate, that is, the primary crystallization which causes a decrease in volume and the secondary adjustment of phases which results in an increase in volume.

Observations on surface tension, creaming, cream viscosity, lipase action, foaming, etc., indicate that it is the adjustment of the surface condi-

tions of the fat globules, as produced by the crystallization which occurs in the first few hours, which is most important in controlling the behavior of milk products.

CONCLUSIONS

1. At 0, 5, and 10° C. the maximum contraction of the fat in cooled cream occurs in about 4 hours. At 15 and 20° C. contraction of the fat may take place over a period of months.

2. At 0 and 5° C. after the maximum contraction of the fat in cream, a slow expansion occurs for two months or more. This second stage of expansion is probably a phase adjustment following the initial rapid crystallization of the fat.

3. The adjustment of the physical state of the fat globules which at low temperature approaches completion in about 4 hours, is the important change which alters the surface properties and adsorption on the fat globules, and influences such properties as cream viscosity, creaming, surface tension, foaming, lipase, etc.

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STUDIES ON THE COMPOSITION OF BOVINE BLOOD

I. THE MAGNESIUM CONTENT OF THE BLOOD PLASMA OF THE NORMAL DAIRY CALF*

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A study of some of the constituents in the blood of dairy cattle was undertaken as a phase of a more comprehensive investigation of the problem of requirements and metabolism of certain elements by dairy cattle in relation to the occurrence of deficiency diseases and with special reference to the use of home-grown feeds for economical milk production. During the past few years our attention has been directed towards a study of the magnesium requirements of cattle (1–4). In extending this investigation it was found desirable to determine the concentration and normal variations of this element in the blood plasma of growing calves over long periods of time since a review of the available literature on the magnesium content of calf blood indicated a general lack of agreement concerning the normal concentration in the blood of calves at various ages. A systematic study, therefore, has been made in which the magnesium, calcium, inorganic phosphorus, chloride and carbon dioxide content has been repeatedly determined from birth to 18 months of age with special reference to the influence of growth and environment under normal conditions of calf management.

Theiler, Green and du Toit (5) reported a value of 6.5 mg. of magnesium per 100 cc. of whole blood for a calf 24 hours after birth. Green and Macaskill (6) found that the concentration of magnesium in the whole blood of a cow and calf was higher than in the plasma and that about two-thirds of the magnesium was in the corpuscles and one-third in the plasma. Normal magnesium values of young calves were found to vary from 2.25 to 2.75 mg. per cent according to Sjollema (7) but the values for calves from 9 to 10 months of age were given as 1.6 to 1.8 mg. per cent. Přibyl (8) found that the serum magnesium varied from 1.21 to 2.24 mg. (average 1.97 mg.) in four suckling calves and that these values were within the same range as their dams.

Allcroft and Godden (9) reported that the serum magnesium values of calves at birth were definitely lower than the normal value for the dam and remained so for the first two weeks. Their mean value obtained from 55 determinations on calves from birth to 28 days of age was 1.79 mg. per 100 cc. (range 1.12–2.25 mg.), whereas the mean value obtained from 32 de-

Received for publication May 6, 1938.

* Published with the permission of the Director of the Experiment Station as Journal Article No. 322 (n.s.).

terminations during the second month of life was 1.97 mg. (range 1.47–2.50 mg.). Groenewald (10) concluded from a series of determinations that the mean magnesium value was 3.09 mg. per 100 cc. of blood plasma for calves from 1 to 85 days of age (range 2.3–4.2 mg.). He also observed that the magnesium content of calf blood was slightly higher than that of cows' blood and that there was no decline of this element in calves' blood during the first three months of life. Malý (11) reported that the blood magnesium of suckling calves ranged from 1.29 to 2.24 mg. (average 1.72 mg.). We (1) have previously indicated that normal plasma magnesium values varied from 2.25 to 2.75 mg. for calves from birth to 300 days of age. Under the conditions of the experiments reported by Herman (12), the average normal serum magnesium value of calves from 8 to 369 days of age was 3.23 mg., with variations from 2.53 to 4.72 mg.

The present paper is the first report of a series of investigations concerning the normal concentrations, variations, and relationships of certain constituents in the blood of growing and mature dairy animals, in health and disease, and deals specifically with plasma magnesium.

METHODS

Several important considerations governed the routine of this experiment. An effort was made to obtain comparable samples of blood from calves which were representative of normal practice in calf management. The blood was always withdrawn in the morning about one hour prior to the regular feeding time so the influence of food was a negligible factor. A uniform procedure was also adopted for the withdrawal of the blood and its disposition after being received in the laboratory. In no instance was the blood allowed to stand at room temperature for any length of time. The routine analytical procedure for the determination of plasma magnesium has been previously reported (1). In nearly all cases it was possible to check the results by a duplicate determination and such checks were invariably within reasonable agreement (± 5 per cent or less of the magnesium determined). The significance of the results is further enhanced by the fact that one person (C. C. L.) was responsible for all of the determinations.

Samples of blood from 107 calves (86 Holsteins, 14 Jerseys, 4 Guernseys, and 3 Brown-Swiss, of which 47 were males and 60 were females) were obtained every week or every two weeks. In a few cases less than 10 samples of blood were obtained but in other cases it was possible to obtain the samples during the entire period. The average number of samples from each calf was 21.

Rations—The calves used in this investigation received whole milk twice a day from birth to 60–90 days of age in amounts according to the needs of each calf, after which time they were changed to a ration of skim

milk. The skim milk was discontinued at 5–6 months of age. A mixture of corn and oats, equal parts by weight, was fed as soon as the calves would eat it and alfalfa hay (U. S. No. 2) was also fed ad lib. from the same time. Corn silage was fed after the calves were 4 months of age. Water was offered twice a day until they were placed in stanchions at about 1 year of age after which they were watered by individual water bowls. The heifers were turned outside during the day for exercise except during inclement weather. They were also pastured on June grass or alfalfa pasture during the pasturing season after they were 10 months of age.

The protein content of the alfalfa hay averaged 15 per cent whereas the phosphorus content was less than 0.2 per cent.

RESULTS

The statistical evaluation of the results are recorded in Table 1, supplemented by a histogram (Fig. 1) and a graph (Fig. 2). The data

TABLE 1

Effect of age on plasma magnesium

Age	Determinations	Mean	Min.	Max.	S.D.	P.E.	C. of V.
mo.	no.	milligrams per 100 cc. of plasma					per cent
0.5	163	2.389 ± 0.015	1.78	3.14	0.287	0.194	12.01
1.5	259	2.345 ± 0.014	1.64	3.33	0.334	0.225	14.24
2.5	260	2.345 ± 0.015	1.62	3.33	0.360	0.243	15.35
3.5	244	2.322 ± 0.014	1.66	3.27	0.323	0.218	13.90
4.5	230	2.407 ± 0.015	1.67	3.36	0.341	0.230	14.16
5.5	173	2.415 ± 0.020	1.78	3.67	0.385	0.260	15.94
6.5	115	2.429 ± 0.025	1.74	3.65	0.390	0.263	16.06
7.5	112	2.441 ± 0.023	1.66	3.43	0.365	0.246	14.95
8.5	93	2.471 ± 0.028	1.84	3.71	0.400	0.270	16.18
9.5	96	2.428 ± 0.030	1.84	3.75	0.431	0.291	17.75
10.5	98	2.535 ± 0.031	1.71	3.60	0.457	0.308	18.02
11.5	91	2.591 ± 0.032	1.87	3.65	0.449	0.303	17.32
12.5	72	2.589 ± 0.034	1.99	3.63	0.430	0.290	16.60
13.5	67	2.445 ± 0.038	1.83	3.67	0.461	0.311	18.85
14.5	59	2.470 ± 0.037	1.84	3.77	0.424	0.286	17.16
15.5	52	2.403 ± 0.035	1.84	3.83	0.369	0.249	15.35
16.5	51	2.431 ± 0.033	1.97	3.38	0.353	0.238	14.51
17.5	51	2.531 ± 0.036	1.86	3.72	0.384	0.259	15.16
Combined	2286	2.414 ± 0.005	1.62	3.83	0.378	0.255	15.65

presented in the table were derived from 2286 analyses of blood plasma from calves from birth to 18 months of age, and show the number of determinations made for each of the 18 months, the mean magnesium value and its probable error for each month expressed in terms of milligrams per 100 cc. of blood plasma, the minimum and maximum value for each month, the standard deviation, probable error, and the coefficient of variation for each of the periods under consideration.

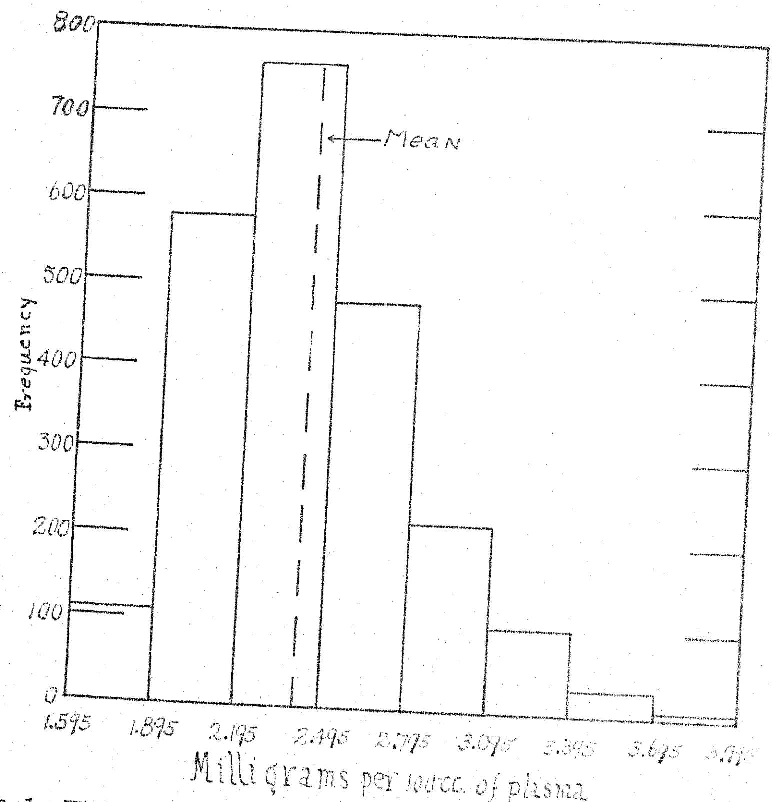

FIG. 1. Histogram showing grouped frequency distribution in variation of 2286 plasma magnesium values from 107 normal dairy calves.

In a frequency distribution table (unpublished basic data) from which the data in Table 1 were derived, the data were classified into 23 classes with an interval of 0.10 mg. between each class. By dividing the data into this number of classes a fairly uniform distribution was obtained. The

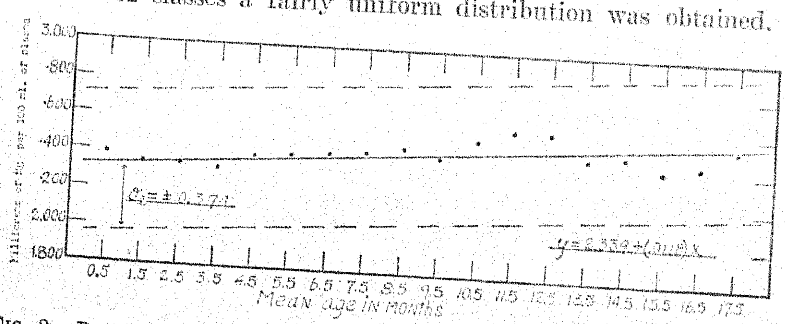

FIG. 2. Dots represent the observed mean plasma magnesium values of normal calves from birth to 18 months of age and the straight line obtained from the experimental data by the method of least squares.

histogram (Fig. 1) was constructed by grouping the data in the frequency distribution table into class intervals of 0.30 mg.

DISCUSSION

From an analysis of the results obtained by the repeated determinations of magnesium in the blood plasma of growing calves, it is evident that both the absolute and relative amounts of this element were subject to considerable variation. It will be seen at once that the mean values obtained are at some variance with those recorded in the literature. Our mean values are definitely higher than some that have been reported (7, 8, 9, 11) and definitely lower than others (5, 10, 12). The significance that may be attached to any series of determinations of magnesium in the blood depends largely upon the conditions under which the determinations were made. There are many factors which may affect the values obtained, including the method of analysis and the particular procedure employed in carrying out a given method. When all other conditions are uniform irregularities in handling the blood after it is drawn will give rise to surprisingly large differences in the values obtained. Permitting the blood to stand at room temperature or to be stored in a refrigerator for some length of time tends to increase the magnesium in the blood plasma. It is desirable to emphasize the fact that the results recorded above are to be viewed as results obtained under certain prescribed conditions which differ in many respects from those governing the determinations made by other investigators.

The values obtained for magnesium may be regarded as showing fairly close agreement for the ages under consideration. It is important to state, however, that all of the 47 male calves had been removed from the investigation by the time they were six months of age. The values recorded in Table 1 for the first six months represent the mean values obtained for both male and female calves. The data for each sex were statistically analyzed and no significant differences were noted for the period under consideration. Starting with the seventh month the mean values are for female calves only.

The extreme difference between the lowest and highest mean value (2.322 mg. for the 4th month and 2.591 mg. for the 12th month) is only 0.268 mg. or 11.1 per cent of the mean for the entire 2286 values. The limits of the probable variation from the trend line in Fig. 2 as determined by the standard error of prediction of the combined results are ± 0.374 mg. per 100 cc. of plasma, whereas the extreme limits of observation indicate an actual difference in the magnesium content of the plasma of normal calves of over 100 per cent.

Another important feature of these results is the array of the observed means about the predicting line. The prediction curve and the dots representing means (Fig. 2) show the goodness of fit of the means of the

observed values to the prediction curve derived by the method of least squares from the correlation table (unpublished). In a normal distribution 68.26 per cent of the experimental values will fall between $-1\ \sigma_e$* and $+1\ \sigma_e$, whereas under our experimental conditions. 72.5 per cent of the observed values actually occurred between $\pm 1\ \sigma_e$. On the basis of probability, the chances are 2.64 to 1 that any experimental value will be found within one standard error of prediction above or below the trend line. It is also interesting to note that Fig. 2 shows two types of variation. One of these is progressive in character and represents a gradual increase in the magnesium values from birth to 18 months of age. This gradual change in concentration is also accompanied by clearly defined series of rhythmic variations which extend over periods of several months. The first variation occurred during the first 4 months of life during which time there was a slight downward trend. This trend was reversed during the 5th month and the maximum value was established during the 12th month. During the next 6 months the direction was mixed but the mean values for the 17th and 18th months were definitely lower than the 12th and 13th months. The coefficients of variation were highest from the 10th to the 15th month, indicating, probably, a period of physiological disturbances. The figure indicates, however, that neither of these conditions represent a continuous movement in either direction and that high or low values were not maintained indefinitely.

The histogram (Fig. 1) shows fairly close agreement in the frequency with which values of a given magnitude occurred and the amount of asymmetry obtained from the distribution of all values. The coefficients of variation are comparatively large (12.01 to 18.85 per cent) but values between 1.895 and 2.795 mg. of magnesium per 100 cc. of plasma occurred with great frequency (79.7 per cent of all observations), while values below 1.895 and above 2.795 mg. were by no means rare. The extreme limits of observation indicate a potential difference in the magnesium content of the plasma of normal calves of over 100 per cent, whereas the limits of variation between 1.895 and 2.795 mg. indicate a difference of only 37.3 per cent of the mean for all months. This difference is large in absolute value and large in terms of percentage of the mean for all months. It is safe to assume, however, that the mean value obtained for each month indicates an actual difference in the concentration of magnesium in the blood from month to month.

Progressive changes in the chemical composition of the blood can, under certain conditions, be accounted for in various ways, but no satisfactory explanation can yet be offered for the factors which determine the level of magnesium or the factors which cause the periodic variations in the level of plasma magnesium in the growing bovine. The magnesium content of

* σ_e = Standard error of prediction.

the blood depends primarily upon the intake and utilization of magnesium, its storage and release from the tissues and skeleton and also upon the rate of growth.

SUMMARY AND CONCLUSIONS

Determinations of magnesium were made on the blood plasma of 107 normal dairy calves at intervals of 1 to 2 weeks over a period of 3 years. Values were calculated for the mean concentration of magnesium in the blood plasma for the first 18 months of life. The mean magnesium values showed fairly close agreement from month to month and a definite tendency to increase up to 12–13 months of age. The change in level was accompanied by a series of rhythmic variations which extended over several months. The mean value for all of the observed values was 2.414 mg. per 100 cc. of blood plasma (range 1.62–3.83 mg.) and 79.7 per cent of the values were between 1.895 and 2.795 mg. (Fig. 1), whereas 72.5 per cent of the values actually occurred within the limits established by the band of normality (Fig. 2).

The values for magnesium, as recorded above, may be regarded as a cross-section of results obtained from a fair sample of normal dairy calves and may be used as a standard of comparison in estimating the probable significance of other determinations. From the evidence obtained in these experiments, one must conclude that the mean values obtained for the concentration of magnesium in the blood of young dairy animals from month to month differ significantly from values obtained by other workers.

It has been shown that the concentration of magnesium can not be regarded as constant. The range of the so-called normal variation is in all probability sufficiently wide to include many variations that occur under pathological as well as physiological conditions since the maximum and minimum values for each month are definitely outside of the limits of the band of normality established for the combined values of the prediction curve. The results of this investigation also make it evident that fluctuations in the plasma magnesium content of the blood of growing dairy calves are to be expected as normal occurrences.

The authors wish to express their appreciation to Dr. W. D. Baten for his assistance with the statistical treatment of the data.

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FASTING ENERGY METABOLISM DURING LACTATION*

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What is the energy requirement for physiologic maintenance[1] in the lactating dairy cow? Important as it is in the evaluation of energetic economy or efficiency of lactation, this question has not been answered satisfactorily in the pertinent literature. The common practice has been to substitute the so called basal metabolism[1] of a dry cow or a steer for the physiologic maintenance requirement of a lactating animal. Yet, it is well known that production of normal milk volume necessitates the feeding of twice to three times the energy required to maintain the dry animal, and that this extra energy intake is not wholly represented in milk energy yielded. We should like to know what part, if any, of this rather huge energy intake is actually necessary to change unit metabolizing tissue from the non-productive to the productive state, and what part is lost as heat increment of feeding. Graham Lusk (1) concluded that there was no difference in the basal energy production[1] in lactating and non-lactating women. But, it seems unbelievable that such can be true also for the dairy cow, an animal in which the persistency and quantity of milk production have been greatly enhanced through generations of selective breeding.

To determine the physiologic maintenance level an animal must be fasted until the specific dynamic effect of the previously ingested food reaches a minimum value. This requires about two days in the ruminant, and causes a decrease in milk yield. The question may therefore be raised as to whether a cow continues to lactate, in the true sense of the word, when subjected to such treatment. Some investigators, in fact, believe that a fasting animal is not a normally lactating animal because of the decline in milk yield. The dairyman on the other hand commonly considers lactation to continue as long as any milk is produced. However, lactation itself is believed to be a physiologic function, whereas milk yield is simply a result of lactation. If, as recent work suggests, lactation is regarded as an endocrine-stimulation of an energy-converting system between milk precur-

Received for publication May 9, 1938.

* Paper No. 171 in the Herman Frasch Foundation Series. Contribution from the Department of Dairy Husbandry, Missouri Agricultural Experiment Station Journal Series No. 565.

1 Physiologic maintenance is a term recommended by the Committee on Animal Nutrition, National Research Council, to refer to the energy necessary for maintenance of energy equilibrium under ideal conditions of environment. While physiologic maintenance and basal metabolism are synonomous in that both represent a level of energy production during fasting, the former is preferable for ruminants, since it is doubtful if these animals ever reach a post-absorptive state comparable with humans.

sors and milk constituents then we may reasonably believe that it may persist quite normally during fasting. The latter point of view appears justified for the following reasons: 1, The reduction or even cessation of milk flow by fasting or failure to remove formed milk have no apparent effect, within certain limits, upon the ability of the animal to again yield a normal quantity of milk after removal of the inhibition (2, 3,); 2, A falling milk yield is compensated in part at least by changes in the percentages of milk constituents. This is true particularly for milk fat, its position as primary, energy-yielding, milk constituent being increasingly emphasized during fasting.

This report presents preliminary data obtained from fasting energy metabolism studies with a lactating and a dry dairy cow, which were subjected to the same conditions of environment and treatment. The main objectives of these studies were, 1, to ascertain how the fasting heat production curves of the lactating and dry cow were related; and, 2, to find if a physiologic maintenance level could be measured during lactation. As a working basis, lactation was assumed to be an endocrine-stimulated energy-converting system, not necessarily measured by quantity of milk produced. It was further assumed that such an endocrine-stimulated activity may reasonably be placed in the category with other activities such as the circulatory, respiratory, heat regulating, and excretory mechanisms, which are usually considered quite resistant to such physiological stress as fasting.

EXPERIMENTAL

The fasting heat production of an eight year old Guernsey cow in the fourth month of lactation and an eight year old Jersey cow which had been dry for over a year was measured by an open circuit-mask respiration method which has been described previously (4). Energy metabolism was computed from the respiratory quotient[2] and volume of directly expired air obtained from the animals in a lying position, in respiration periods of 20–30 minutes duration. The respiration periods were started as soon as possible after consumption of the last feed, and were repeated about every two hours during the first 12 hours of fast and about every 3 to 5 hours thereafter. Corresponding periods for each animal were carried out at approximately the same time of day or night and interval after feeding.[3] Prior to fasting each animal was given feed of equal quality and quantity. Between respiration periods the animals were kept in adja-

[2] Total respiratory quotient, uncorrected for urinary nitrogen, but corrected for fermentation methane and carbon dioxide, determined by gas analysis with Haldane apparatus.

[3] Immediately after ending a period on one cow the other animal was started. About 5 minutes intervened between the periods of each animal to insure complete washing out of apparatus for gas sampling.

cent metabolism stalls (5), and were at all times subjected to the same manner of handling and environmental temperature (thermal neutrality). The lactating cow was milked regularly at 6 o'clock a.m. and p.m.

The resulting data are presented in Fig. 1 and Tables 1, 2, and 3.

TABLE 1

Average daily live weight, food and water consumption and excreta production during preliminary feeding periods

Animal	Live Weight	Hay[a]	Silage[b]	Grain[c]	Water	Milk	Feces	Urine
	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.
#428 Lactating ...	373.2	4.709	11.693 8.711*	3.178 1.589*	28.820	6.171	19.866	7.556
#831 Dry	504.1	2.954	10.536 6.910*	3.178 1.589*	26.199	....	18.289	8.657

[a] 5.0 Kgs. good quality alfalfa hay offered at p. m. feeding.
[b] 13.0 Kgs. silage offered at a. m. feeding.
[c] 1.589 Kgs. grain mixture offered at a. m. and p. m. feedings.
* Last feed before fast. Average for Experiments 2 and 3.

TABLE 2

Average milk and fat production during fasting
(Average for 3 trials)

Period	1	2	3	4	5	6
Hours fasting	12	24	36	48	60	72
Milk (Gms.)	2765	3111	2026	2006	1262	1612
Fat (Gms.)	134.9	153.1	135.0	136.8	98.4	137.0

DISCUSSION

While these data leave much to be desired, they point to some interesting aspects of energy metabolism in the dairy cow. Figure 1 shows that changes in fasting heat production are in general similar for both cows. In both animals the energy metabolism declines to about 47 per cent of the initial value within 48 hours after the last food is consumed. The absolute heat production (top chart) is about the same for a 750-pound lactating cow and a 1100-pound dry cow, each receiving the same kind of feed to the limit of appetite. Compared on a physiological weight basis (7), the heat production (middle chart) by the lactating cow is of the order of 20 per cent higher than that of the dry cow. This difference remains constant up to 60 hours fasting. Corrected further for gross energy intake (bottom chart), the energy production curve for the lactating cow is 10 per cent higher than that for the dry cow. Any attempt to interpret curve II (bottom chart) would be idle speculation with the data at hand. This curve may indicate that in the lactating cow, 1, an increasing rate of energy

TABLE 3

Average daily body weight loss, nitrogen excretion (milk and urine), and fecal output during fasting

Period of fasting	Weight loss Kgs. per 72 hrs.	Nitrogen excretion Gms. per 24 hrs.[a]	Fecal output Kgs. dry matter per 24 hrs.[b] Ballast[c]	Feces	Per cent loss
		#428 Lactating Cow			
First 12 hrs.		91.990	10.979	4.131	37.6
12–36 hrs.		87.439	6.848	2.603	38.0
36–60 hrs.		41.360	4.245	1.271	29.9
60–72 hrs.		71.972	2.974	0.502	16.9
Average	25.117	66.924 (12–72 hrs.)	......	......	......
		#831 Dry Cow			
First 12 hrs.		129.122	8.507	3.605	42.4
12–36 hrs.		83.142	4.902	1.437	29.3
36–60 hrs.		66.509	3.465	0.342	9.9
60–72 hrs.		51.633	3.123	0.137	4.4
Average	26.346	67.095 (12–72 hrs.)	......	......	......

[a] Uncorrected for specific gravity—assuming 1 gm. per cc. of urine or milk.

[b] Dry matter computed as follows: hay, 90%; grain, 90%; silage, 30%. Fecal dry matter assumed to be same for lactating and dry cow; about 20.1%. Also assuming that dry matter percentage remains fairly constant during fasting. See Benedict & Ritzman (6).

[c] Initial ballast assumed to be proportional to: *Daily dry matter intake − Daily dry matter of feces + Dry matter intake of last feeding.* Ballast for succeeding periods computed by subtracting fecal output from ballast in preceding period.

utilization occurs after 36 hours fast; or, 2, that heat increment per unit energy absorbed increases, possibly along with a declining demand for maintenance energy; or, 3, that body tissue becomes increasingly more important as a source for milk energy. In this connection it might be stated that loss in weight during fasting was apparently no greater for the lactating cow than for the dry cow. This is shown in Table 3 and further substantiated by the nitrogen excretion values in the same table.

A striking difference in the energy production of these cows is shown by the break in the curve for the lactating animal occurring after 60 hours of fast. The heat production level reached by both cows at 36–48 hours is maintained at least until 72 hours by the dry cow, but in the lactating cow it further declines about 20 per cent between 60 and 72 hours. This drop in total metabolism of the lactating cow at first thought seems fortuitous, but when considered in the light of other data presented herein it takes on significance. Table 3 shows that at 72 hours after food the lactating cow excreted feces at a rate about 400 per cent greater than the dry cow. Since these animals continued to excrete considerable quantities of methane,[4] even

[4] Methane excretion variable. Average value about 1.5 liters per hour between 36 and 72 hours fasting.

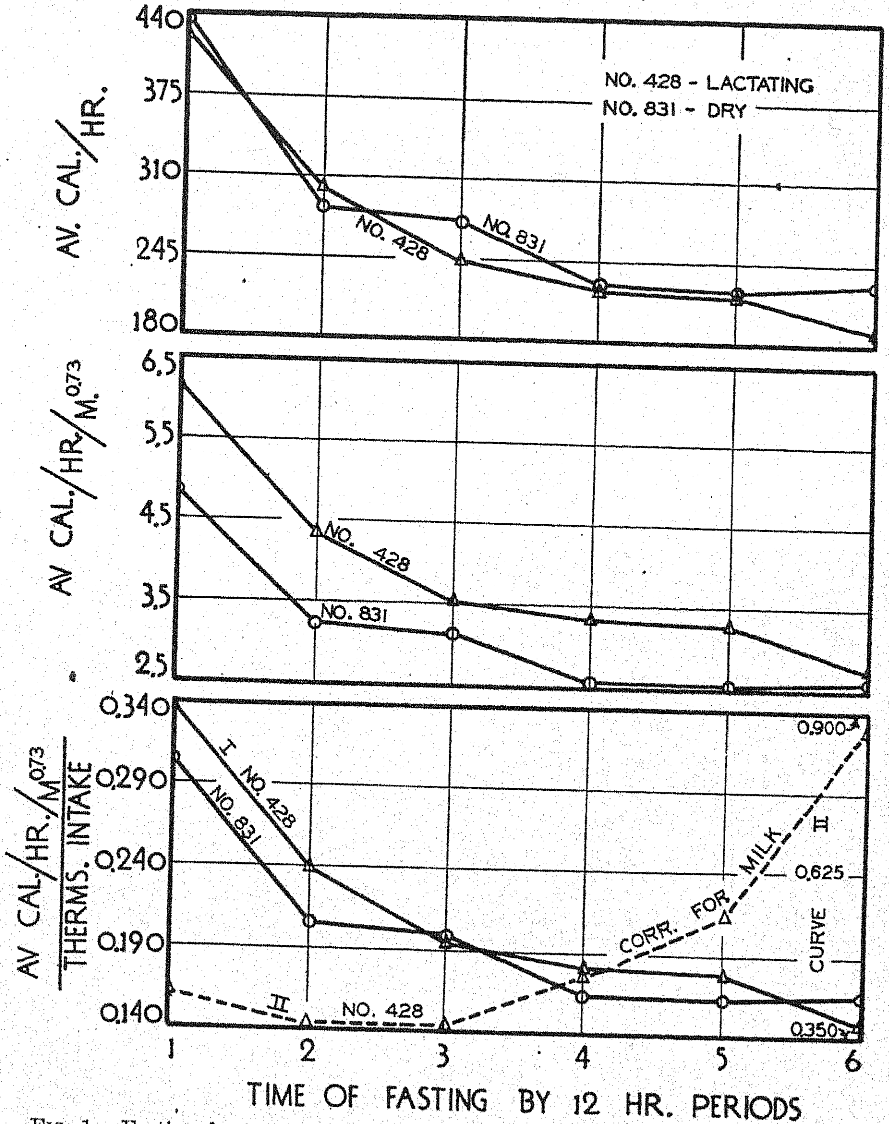

FIG. 1. Fasting heat production curves for lactating Guernsey cow No. 428 and dry Jersey cow No. 831. Top chart—total heat production (avg. for 2 fasting experiments). Middle chart—heat production per unit physiologic weight (0.73 power of live weight in kilograms). Bottom chart—values in middle chart further corrected for differences in energy intake (Therms). Curve II for cow No. 428 obtained by dividing values given in middle chart by gross energy intake minus milk energy (Therms).

at 72 hours, it appears that fermentative digestion and absorption were going on. Thus a certain part of the total heat production, even after a level had been attained, might have been due to heat increment of nutri-

ment absorbed from alimentary residue. The rapid rate of evacuation of the digestive tract by the lactating animal would then result in a decline in absorption and a drop in total heat production. In other words the lactating cow might have been approaching the so called hypothetical minimum energy production more quickly than the dry cow. Inasmuch as the hypothetical minimum metabolism of the ruminant has never been reported, we do not know how to apportion the total heat production during fasting between heat increment and the so called tissue metabolism.

It does not seem impossible that, under the strain of fasting, extra-mammary systems in the lactating animal might compensate by subsisting on a lower maintenance plane, so that mammary activity might be prolonged. Despite the common opinion that lactation stimulus elevates the level of energy metabolism of body tissue in general, no evidence has yet been advanced to show whether the increased total metabolism in lactation is due to elevated tissue metabolism or to increased heat increment of feeding. Apparently, increased food consumption is a factor in the higher metabolism of lactating cows stimulated by thyroxine (8, 9). It is well known that thyroxine stimulation in humans and other animals also results in greater food intake and tissue breakdown. Moreover, recent observations indicate that secretions of the pituitary (10, 11) and adrenal glands (12) act upon the alimentary system and are important factors in the absorption of nutriment.[5] Is it not justifiable then to assume that the endocrine stimulus of lactation acts in a large degree upon the alimentary system, making for greater nutriment absorption and hence a greater heat increment from nutriment? Of course it can be argued that greater food intake in lactation is caused by a greater demand of body tissue for energy. In this connection, however, one must remember that food intake is regulated essentially by appetite or hunger manifested by characteristic sensations and activity of the alimentary system, not by body tissue in general.

Another possible cause for the drop in total metabolism of the lactating cow might be the breakdown and disappearance of some metabolism stimulating mechanism associated with lactation. It is possible that at 60 hours the heat production of the lactating animal begins to approach that of the dry animal, finally reaching such a level upon complete cessation of milk secretion. The data in Table 2, however, do not seem to substantiate this reasoning, at least within the limit of 72 hours of fast. It appears that the fat synthesizing mechanism endured with remarkable constancy during the entire experimental period. Furthermore, when corrected for energy intake in the feed the total heat production of the lactating animal drops below that of the dry animal at 72 hours.

[5] While thyroxine and the pituitary and adrenal hormones are referred to in this connection merely as an example, they are also thought to be important factors in lactation stimulus.

SUMMARY

Preliminary data obtained by an open-circuit-mask respiration method indicate that the total heat production of a lactating cow during fasting is about 10 per cent higher than that of a dry cow. Up to 60 hours of fast the heat production curves of both animals are essentially parallel, reaching a level at about 36 to 48 hours after feed. After 60 hours the heat production of the lactating animal further declined about 20 per cent. Certain data indicate that the higher level of total energy metabolism in the lactating cow is in a large measure due to heat increment of nutriment.

During 72 hours of fast, the lactating cow continued to produce a relatively constant amount of milk fat, although her milk yield declined about 50 per cent. It is believed, therefore, that within the limits of these experiments, lactation as a mechanism was unchanged by fasting.

Further investigation of digestion, absorption, and incident heat increment of nutriment appears to be necessary in order to evaluate true physiologic maintenance in the fasting ruminant. The probability of considerable absorption occurring 72 hours after food, suggests that the fasting level of total heat production is not an accurate measure of physiologic maintenance in the ruminant. Furthermore, differences in the speed of movement of alimentary residue during fasting, indicate that the fasting levels of total heat production in the lactating and dry cow are not comparable without further correction.

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EFFECTIVENESS OF ULTRAVIOLET LIGHT APPLIED TO THE HEAD OR BACK REGIONS OF CALVES

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While considering an installation of ultraviolet lamps in a dairy barn the question arose as to the position of the lamps with respect to the cow's body. It was known that solar irradiation of the cow increases the vitamin D content of milk (1) as does irradiation with artificial sources of ultraviolet light (2, 3, 4) although the evidence on this point is conflicting (5, 6). Calves undoubtedly can use ultraviolet from solar or artificial radiation to alter their blood chemistry and mineral metabolism to such a degree as to prevent or cure rickets (7, 8, 9). From the work just cited, however, there is no means of determining what regions, if any, of the cow's body are particularly penetrable to ultraviolet light. In other species marked differences in the effectiveness of ultraviolet have been demonstrated by directing the radiation at different body sectors (10, 11, 12).

Of particular interest in this respect is the work of Knudsen (13) who showed that in rats radiation of the head region was much more effective than radiation of the back. He also found that the hair on the back probably was preventing absorption of the ultraviolet because when shaved areas were exposed marked antirachitic effects were obtained.

As preliminary, the work of Knudsen was partially repeated. Rachitic rats were irradiated for various periods with a Cooper-Hewitt lamp at a distance of 30 inches. In addition to substantiating the work of Knudsen the data in Table 1 suggest the significant point that if the radiation is continued long enough considerable ultraviolet penetrates the unshaved back.

TABLE 1
Response of rachitic rats to ultraviolet light

Part of body exposed	Length of exposure	No. of rats	Av. line test
	min.		
Head	120	2	3.00
Back (unshaved)	120	2	0.75
Controls	......	2	0.00
Head	60	4	0.88
Back (unshaved)	60	4	0.38
Controls	......	4	0.00
Head	30	2	0.00
Back (unshaved)	30	2	0.00
•Back (shaved)	30	5	1.20
Controls	......	3	0.00

Received for publication May 10, 1938.

These findings with rats prompted a study with calves which, it was hoped, might throw some light on the question of placement of ultraviolet lamps in a dairy barn installation.

EXPERIMENTAL

Three groups of three calves each were used in this experiment. All the calves received whole milk in amounts sufficient to meet their needs during the first few weeks. They were then gradually shifted to liquid skimmilk which was fed at a maximum of 16 pounds daily. The calves were fed a grain mixture composed of equal parts ground yellow corn and ground oats. At the end of 120 days skimmilk feeding was discontinued. Water and salt were given free choice to all calves. The calves were penned in groups of three, each pen being provided with stanchions so that the animals could be treated as individuals. Raised slatted floors eliminated the use of bedding.

The calves in Group I were irradiated directly on the face and head by ultraviolet lamps placed in front of the head position of each calf as it stood in a stanchion. The calves in Group II were irradiated on the back by lamps placed above the center of the back region of each calf as it stood in a stanchion. In order to restrict the treatment to the desired region each group of calves was draped with a black cloth which prevented the light from striking anywhere but on the head region of the calves in Group I and screened the head region from the light in Group II. Group III served as controls and received no ultraviolet light. The lamps used were of special design to meet the needs of the set-up.[1]

Measurements were made monthly with an ultraviolet meter of the light intensity on the heads and backs of the respective groups. Readings were made at several points of the head and back areas. Any required equalization of ultraviolet intensity was accomplished by adjusting the height of the lamps in the back-irradiated group. The average intensity of ultraviolet light reaching the calves' heads was 82, and that reaching the calves' backs 84, micro-watts per square centimeter. The calves in Groups I and II were exposed to the lights for 45 minutes daily, including a 10 minute warming up period. It is estimated that the daily exposure to ultraviolet light was approximately equal to 2 hours of midsummer sunshine.

At the beginning of the experiment, and at approximately monthly intervals thereafter, blood samples were taken from each calf and the amount of calcium and phosphorus in the serum was determined. The Clark-Collip method for calcium (14) and the Bell-Doisy-Briggs procedure for phosphorus (15) were followed. At the same time blood from the calves of each group was pooled and dried before fans in a hot air chamber. These samples of dried pooled blood were later used for vitamin D comparisons, using the line test procedure.

[1] The lamps were furnished and the installation and ultraviolet measurements made by the General Electric Co., Nela Park, Cleveland, Ohio.

TABLE 2

Calcium and phosphorus in blood serum of calves
(Mg. per 100 cc.)

Date	Head group						Back group						Control group					
	1G		2H		3H		4H		5J		570H		6J		569H		581H	
	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P
11/16/36	10.99	10.45	11.44	9.40	10.69	8.51	10.59	7.96	10.99	10.45	10.54	8.83	11.34	9.87	11.14	9.17		
12/14/36	9.54	8.20	10.59	9.40	10.74	8.08	10.89	8.08	11.24	10.25	9.34	8.60	10.04	6.99	6.48	9.93		
12/23/26																	11.75	10.80
1/11/37	Dead		10.34	10.00	10.19	8.93	10.89	9.25	10.84	9.57	6.83	8.53	5.82	9.94	5.47	7.88	10.34	9.13
1/21/37											6.98	6.77			4.62	8.65		
2/ 4/37															5.22	7.20		
2/ 8/37			10.79	8.98	10.57	8.26	9.90	8.05	11.14	8.73	Dead		5.57	8.37			8.73	9.33
3/ 9/37			11.10	7.73	10.56	8.18	10.47	7.40	10.13	8.88			5.67	7.47	Dead		5.72	8.33
4/ 7/37			10.42	8.37	10.27	6.70	9.34	7.50	8.85	7.73			6.31	5.56			6.31	7.57
5/14/37			Dead		Dead		10.22 Killed	6.95	Dead				Dead				5.86 Killed	5.42

After each calf died or was killed, the front and rear cannon bones and both eighth ribs were removed and freed of adhering flesh. The breaking strength of the left front and rear cannon bones was determined on an Olsen breaking machine, and the ash content of the distal end (one-third of the length) obtained after extraction with alcohol and ether. The same procedure was followed in determining the ash content of one-tenth of the rib bones, measured from the costochondral end.

The blood calcium and phosphorus data are presented in Table 2. Calf 1 G (head group) refused to eat and died, probably from starvation, early in the trial. Of outstanding significance is the difference between the values for Groups I and II and those of Group III. The control calves developed a blood picture indicative of rickets of the low calcium type. The blood calcium and phosphorus values of the irradiated calves are for the most part within the range of normality except for Calf 570 H, which died at the age of 2½ months from an injury obtained during a violent convulsion. At the time of death the calcium level of this calf's blood was rather low. The other two calves in this group showed normal blood pictures at the time of the death of 570 H. This fact, plus the rather variable results for calcium on calf 4 H, indicating possibly that it was on the borderline, and the somewhat lower calcium value on 5 J shortly before it died, indicates that the back-treated calves did not respond quite as well as did the head-treated calves.

The data in Table 3 substantiate this to some extent. During the first part of the experiment the vitamin D potency of the pooled blood from the

TABLE 3

Vitamin D potency of dried blood (line test procedure)

Date	Amount fed	Line test values		
		Head	Back	Control
	mg.			
11/16/36	500	0.0	0.0	0.0
	1000	0.0	0.0	0.0
	2000	0.0	0.0	0.0
	3000	0.0	0.0	0.0
1/11/37	2000	0.25	0.0	0.0
	3000	0.50	0.15	0.0
2/ 8/37	2000	0.70	0.17	
	3000	.....	.....	0.0
	4000	.....	.....	0.0
3/ 9/37	2000	0.53	0.64	
	3000	.....	.....	0.0
	4000	.....	.....	0.0
4/ 7/37	2000	0.13	0.25	
	3000	0.20	0.25	0.0
	4000	.....	.....	0.0

head-irradiated calves was definitely greater than that of the back-irradiated calves, but towards the end of the experiment there was no measurable difference. This might indicate that at first radiation of the head region was more effective, but as the treatment continued the calves in the back group caught up. It must also be considered that Calf 570 H, whose blood had been running low in calcium, did not contribute blood to the last two pooled samples.

TABLE 4

Ash content and breaking strength of bones

Group	Calf		% ash in bones		Days on exp.	Breaking strength of cannon bones	
			Leg	Rib		Front	Rear
			First analysis—All calves considered				
Head	1		59.52	64.53	58	800	903
	2		58.75	53.02	163	1195	1700
	3		58.53	50.95	148	1135	1458
		Av.	58.93	56.17		1043	1354
Back	4		58.89	52.10	186	1035	1472
	5		55.63	49.56	154	864	1100
	570		52.12	41.12	70	846	1405
		Av.	55.55	47.59		915	1326
Control	6		54.30	34.98	146	812	1142
	569		54.27	46.84	82	1182	1372
	581		51.71	35.67	148	736	1136
		Av.	53.43	39.16		910	1217
			Second analysis *Calves on experiment 5 months or longer*				
Head	2		58.75	53.02	163	1195	1700
	3		58.53	50.95	148	1135	1458
		Av.	58.64	51.99		1165	1579
Back	4		58.89	52.10	186	1035	1472
	5		55.63	49.56	154	864	1100
		Av.	57.26	50.83		950	1236
Control	6		54.30	34.98	146	812	1142
	581		51.71	35.67	148	736	1136
		Av.	53.01	35.33		774	1139

The over-all effect of the various treatments is shown by the data in Table 4. These data may be treated in two ways: 1) when all calves were included; 2) when only those calves on experiment 5 months or longer are included. When the data on all calves are included an appreciable difference is shown between the bone ash content of the head-irradiated group and the back-irradiated group, although no difference in breaking strength is apparent. Again the inclusion of data from Calf 570 H is responsible for the apparent poorer performance of the back-irradiated group. When the data from the calves on trial for 5 months or longer are considered the difference in bone ash between the head group and back group is not signifi-

cant, but breaking strength values favor the head group. No matter which method of treatment is applied both the head and back groups show much better skeletal development than the calves in the control group. This superiority must be attributed to the light treatment.

DISCUSSION

Lower blood calcium and phosphorus, decreased bone ash and breaking strength, lack of vitamin D in the blood, enlarged knees and rib ends, stiffness, and a humped back posture, were symptoms in the control calves indicative of rickets. All the calves exhibited anorexia and failed to grow after skimmilk feeding was discontinued. The feeding of dry yeast did not increase grain consumption.

Most of the calves exhibited tetanic convulsions towards the latter part of the experiment. In a few instances following the spasm the calf would pass into a coma and die, or, if the coma was prolonged, the animal was killed. Magnesium determinations made on the blood just previous to or during a convulsion or coma gave values in most instances under 2.0 and as low as 1.6 mg. per 100 cc. These are below the normal values given for calves by Duncan, Huffman, and Robinson (16). The production of low-magnesium tetany was probably due to insufficient magnesium intake and could not be associated with the light treatment.

So far as practical application of these findings is concerned it would seem that a satisfactory installation of ultraviolet lamps would be one which utilized the greatest possible exposed surface. It would need to be assumed, of course, that cows utilize the ultraviolet in the same manner as do calves.

CONCLUSIONS

Ultraviolet light from artificial sources, of sufficient intensity to equal approximately the radiation received from two hours of midsummer sunshine daily, is effective in preventing rickets in young calves fed a rickets-producing ration.

Ultraviolet light applied to the region back of the withers and with the greatest intensity on the center of the back, is almost as effective as when an equivalent amount is applied to the head region of calves.

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NATURE OF THE SWELLING IN THE UDDER OF A COW AT CALVING TIME

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Dairy cows differ greatly with respect to the amount of swelling in and near the udder at calving time. In some cases the udder undergoes a moderate increase in size but otherwise little visible change. In others it becomes swollen—sometimes to the point of extreme distortion. Not infrequently a "plastic" condition develops that may be limited to the lower portion or may involve a large part of the surface of [illegible]dder. The term "plastic" is used to denote a condition wherein [illegible] pressure, as with the fingertips, leaves a persistent indentation. This condition is often referred to as "pitting." A pronounced case is illustrated in Fig. 1. This kind of swelling usually is cool to the touch. Sometimes the swelling

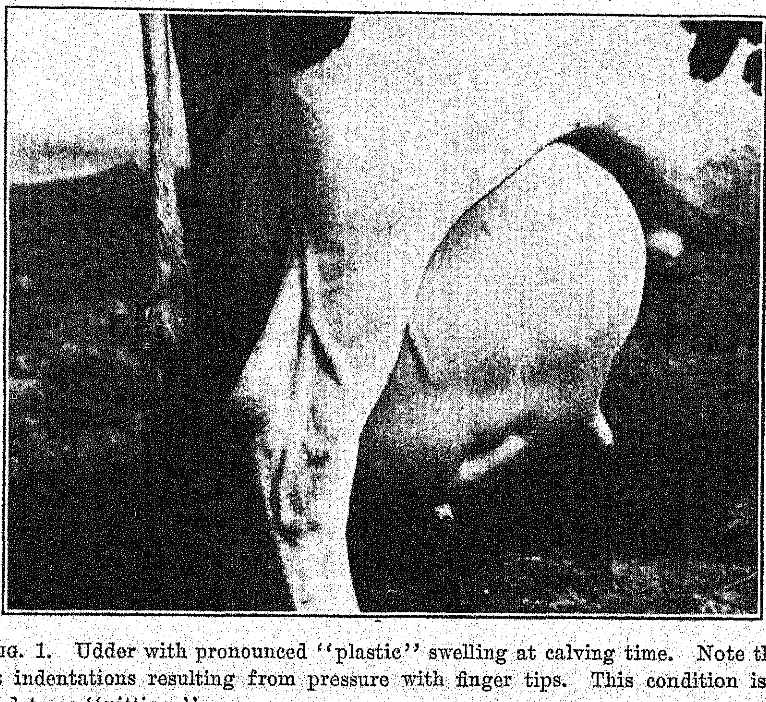

FIG. 1. Udder with pronounced "plastic" swelling at calving time. Note the persistent indentations resulting from pressure with finger tips. This condition is often referred to as "pitting."

Received for publication May 11, 1938.

[1] Acknowledgment is made to S. R. Hall, Assistant Histologist, Division of Nutrition and Physiology, for preparing the slides from which the photomicrographs in Plate 5 were made.

disappears in a few days. Sometimes it persists in some degree for several months.

There is much to indicate that the kind of swelling described is the result of edema. By definition edema is an infiltration of serum in a part. A medical dictionary[2] lists 25 or more different types of edema that occur in humans. It seems to be caused by a great variety of disturbances to the physiological functions of the individual. Lymphedema is a swelling of soft tissues resulting from an increased quantity of lymph. Stoppage of lymph circulation, which is known as lymph stasis, results chiefly from some obstruction which causes the lymph to seek new channels. It appears to be conducive to fibrosis (development of fibrous tissue) which produces further stasis and still more fibrosis.[3] It might be expected, therefore, that repeated edematous swelling would tend to produce large, fibrous udders in cows with advance in age.

An edematous condition involving the udder and sometimes extending forward to the umbilicus and more rarely to the brisket, has been found by Parshall[4] in certain cases of acute gangrenous mastitis. It was found accompanied by coagulated blood-like material in the cisterns, multiple abscesses, blood clots in the large veins, gas pockets in scattered areas and necrosis. This condition, however, occurred most frequently between the second and sixth months of lactation. One case was found in a dry cow and only one in twelve occurred at the time of parturition. Bacteriological examination of the udders showed a mixed infection of *Staphylococcus aureus* and some anaerobes of which *Clostridium welchii* was the most important. Injections of pure cultures of either one of these organisms produced only mild cases of mastitis, but injections of both together resulted in marked edema on the day following injection, and typical gangrenous mastitis in 3 of 6 cows inoculated.

Correspondence has recently been carried on with authorities on edema and on lactation in women to learn whether or not a condition analogous to that found in cows at calving time occurs in the breasts of women at childbirth. One reply states that such a condition has not been observed in women. Another indicates that occasionally some edematous swelling does occur in the human breast at parturition, which is thought to be a lymphatic condition. Apparently it does not occur with sufficient frequency or severity to be considered a serious disturbance in the human.

As a rule udders showing an abundance of the swelling incidental to calving, are not available for post-mortem anatomical study, as dairy cows are

[2] Gould's Medical Dictionary (Scott) Second Edition. P. Blakiston's Son & Co. Philadelphia, Pa. 1928.

[3] Allen, E. V. and Ghormley, R. K. Lymphedema of the Extremities. Annals of Internal Medicine, 9, No. 1, pp. 516–539. 1935. From the Mayo Clinic.

[4] Parshall, C. J. Nature of Experimentally Produced Gangrenous Mastitis in Cows. Cornell Veterinarian, Vol. 24, April 1934. pp. 146–155.

seldom slaughtered at such an early stage of lactation. However, an opportunity was provided for slaughtering a cow that was showing at the time, an extremely congested condition of the udder. The cow was No. 848, a registered Holstein-Friesian, bred and raised in the herd of the Bureau of Dairy Industry, Beltsville, Md.

The usual procedure with all heifer calves in the breeding herd of the Bureau of Dairy Industry, at the Beltsville, Md., Station, is to commence periodic examinations of the comparative development of the mammary gland at an early age. At each examination the status of mammary gland development is graded. Nine grades, ranging from 1 to 9, are used for this purpose. A grade of 1 indicates an extremely retarded development, grade 9 is applied to the most advanced development, grade 5 represents the average development, grades 2, 3 and 4 are below average and grades 6, 7 and 8 are above.

As a young calf the mammary development of No. 848 was definitely below average. Grades of 3 were assigned both at 16 days and at 1 month 27 days of age. At 3 months 2 days the glandular development was graded 2 and the condition was noted as follows: "Udder tissue development appears to be very much retarded. Still in the straight tube stage. About the same development usually found at 2 weeks of age." At all subsequent observations up to the age of 1 year the stage of mammary gland development was below average though some progressive improvement was made and at 18 months the mammary development was definitely above the average. At each observation the udder was characterized by uniformity in the development of the individual quarters and at each examination made between the ages of 9 and 18 months inclusive, the glandular tissue was well attached to the abdominal wall.

Four examinations of the udder were made (Sept. 11 to October 26, 1931) previous to her first calving on November 3, 1931. At the first examination some swelling was noticeable, a grade of 3 for quantity being assigned. The quantity increased steadily, a grade of 5 being given on October 6, a grade of 8 on October 21, and a grade of 9 on October 26—8 days before calving. On October 26 this cow also showed a "very large area of abdominal swelling". After calving the swelling diminished rather steadily, only a very small quantity remaining on February 11, 1932, and only a trace on subsequent monthly observations until August 18, after which it appears to have disappeared entirely. The swelling was moderately plastic in character from October 21 to November 18, 1931.

Udder examinations were not made during the second or third lactation periods, but photographs taken near the time of each calving showed a strong tendency for this cow to develop swelling in the udder at each calving. This was particularly the case at the time of the fourth calving when the size of the udder reached extreme proportions. (Fig. 2.)

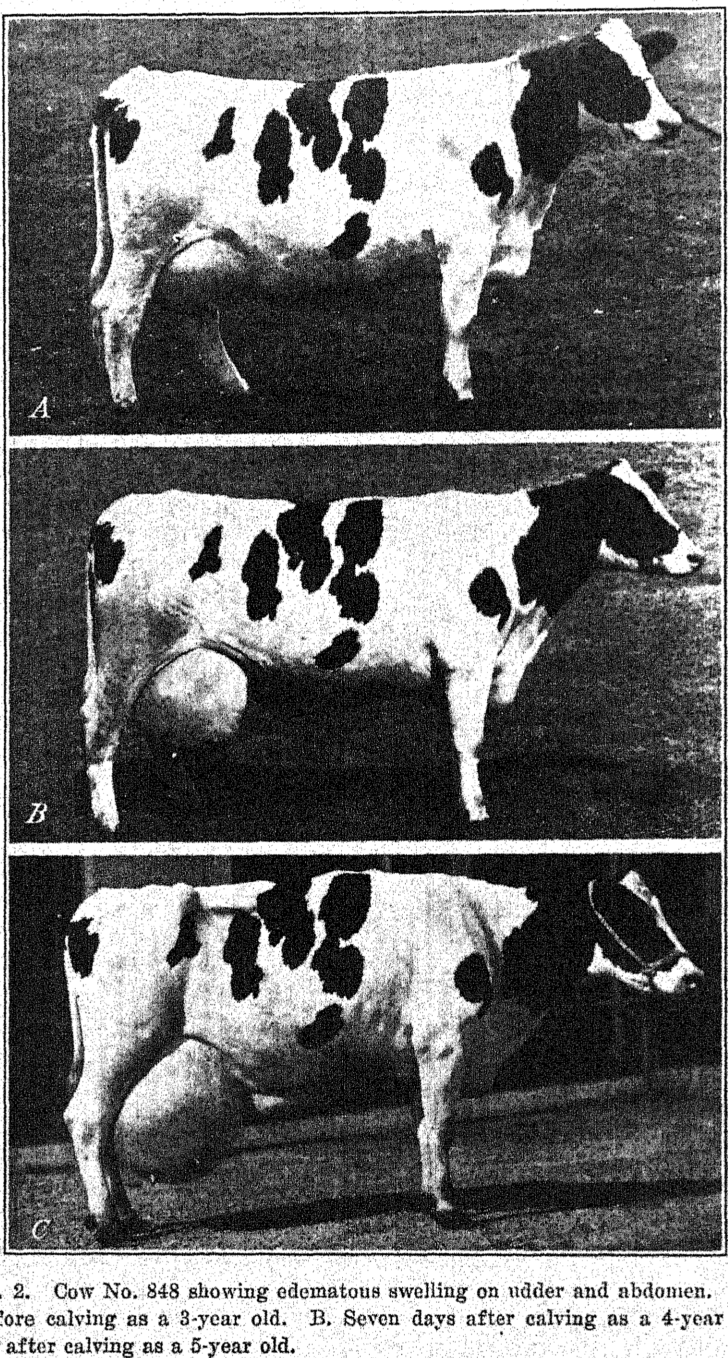

FIG. 2. Cow No. 848 showing edematous swelling on udder and abdomen. A. Five days before calving as a 3-year old. B. Seven days after calving as a 4-year old. C. One day after calving as a 5-year old.

Comments made by the men who milked this cow both by hand and by machine are interesting. She was milked by hand during a large part of her third lactation. The milker states that it was not particularly difficult to squeeze the milk out of the teats but that owing to the short teats and the hard swollen layer at the lower part of the udder, the milking had to be done by stripping between the thumb and finger and 25 to 30 minutes was required for milking. He volunteered the opinion that the swollen condition existing 5 days after calving would have been present to nearly the same extent 5 months after calving, as her udder always stayed hard on the bottom. The machine operator who milked the cow during her first lactation stated that this cow's udder was always hard.

The cow was slaughtered June 11, 1935, after her fourth calving which took place on June 6. Examination of the udder after milking on the morning of slaughter showed it to be of extreme size and to have a very large amount of swelling of a plastic nature. The udder was comparatively poor in shape as Figure 2 shows. It was amputated as quickly as possible after death, and subsequently was filled with formalin and frozen according to the plan regularly followed with cows slaughtered at the Beltsville Station. Although milked out before the cow was killed, the amputated udder weighed 165.65 pounds. This represents 10.9 per cent of the live weight of the cow on June 7—the day the last photograph in Fig. 2 was made.

The procedure followed in post-mortem studies of the udder is to fill the two quarters on one side of the udder simultaneously with formalin under constant pressure. Comparatively few cases (not more than 20 per cent) require more than 7½ minutes to fill the two quarters of the udder, but owing to the extreme size of this udder the filling was continued for 12½ minutes. At the end of that time 24,580 cc. of formalin had flowed into the two right quarters of the udder. Assuming that both halves of the udder had the same capacity the entire udder would have held 49,160 cc. which is equivalent in volume to 111.72 pounds of milk—the calculated capacity of this udder. As soon as filling was terminated the left half (unfilled) was separated from the right half by cutting along the left side of the median septum. The nature of the swelling could be clearly discerned when this incision was made. Apparently it was outside and separate from the glandular tissue, which seemed to be unaffected. The layer of swelling was about 2 inches thick. Describing its appearance is somewhat difficult but it seemed to consist chiefly of clear transparent fluid through which ran a net-work of fine silky fibers, glistening in appearance, that resembled spider's web. The fluid was held in some manner by this lacy structure and no appreciable amount escaped at the time the incision was made. The right half of the udder was immediately placed in a freezing room at a temperature of approximately 10° F., where it was kept until March 11, 1936. On that date it was cut with a band saw into vertical transverse sections approximately 1 inch thick.

After having been kept in a refrigerated room for 12 months the appearance of the layer of swelling was essentially unchanged, the fluid still being held in some manner by the tissues or by the lacy structure noted on the day of slaughter. Apparently the swelling was edematous in character, and the swollen material will subsequently be referred to as edematous tissue. Photographs of the cut surface of these sections were made according to our usual procedure on June 12, 1936. Although these photographs showed the glandular tissue in splendid detail, the lacy structure within the edematous tissue was less clearly brought out. The structure in the vertical transverse plane directly above the rear teat is shown in Fig. 3.

One of the sections was again photographed on March 30, 1937, more than 21 months after the cow was slaughtered, in an attempt to show the structure of the edematous tissue in greater detail. Even after this extended period the tissue did not appear to be appreciably changed. The appearance of both the glandular and edematous areas in this section is shown in Fig. 4, which represents a vertical plane directly above the front teat. The line of separation between the two areas is quite distinct, although there is some indication of a trace of edema in the strands of fiber running through the glandular tissue along the lower edge of the glandular area. To give an idea of the quantity of swelling present it is noted that the distance from the tip of the teat to the end of the skin covering the udder shown at the upper left, measured 17 1/16 inches. Attention is called to the manner in which the hide is pushed away from the glandular tissue, the way in which the right and left halves of the udder have been pushed away from each other, and the extent to which the teat is surrounded and seemingly shortened by the edematous swelling. The apparent shortening of the teat is shown to even better advantage in Fig. 3.

The tenacity with which the fluid was held by the edematous tissue is shown by the lack of change which occurred during the 21 months following slaughter, more than a year of which was after the udder was sectioned. When the udder sections were exposed to warm air, however, there was an evaporation of the suspended fluid and the areas that had appeared to consist primarily of fluid came to resemble a mass of loosely connected fiber.

Small blocks of the fresh tissue were removed on the day of slaughter from the half of the udder not filled with formalin, to be used for histological study. Blocks No. 1 and No. 2 were located 3½ and 10½ inches respectively above the front teat; and No. 3, No. 4 and No. 5, 3½, 9¾ and 16¼ inches respectively above the rear teat. Before the histological studies were completed some evaporation of the preserving solution occurred and blocks Nos. 4 and 5 were spoiled. Slides were made from blocks 1, 2 and 3, of which representative areas are shown in Fig. 5, A, B & C. The structure of the edematous tissue obtained from one of the frozen gross sections and photographed at the same magnification as the other histological areas, is shown in Fig. 5, D.

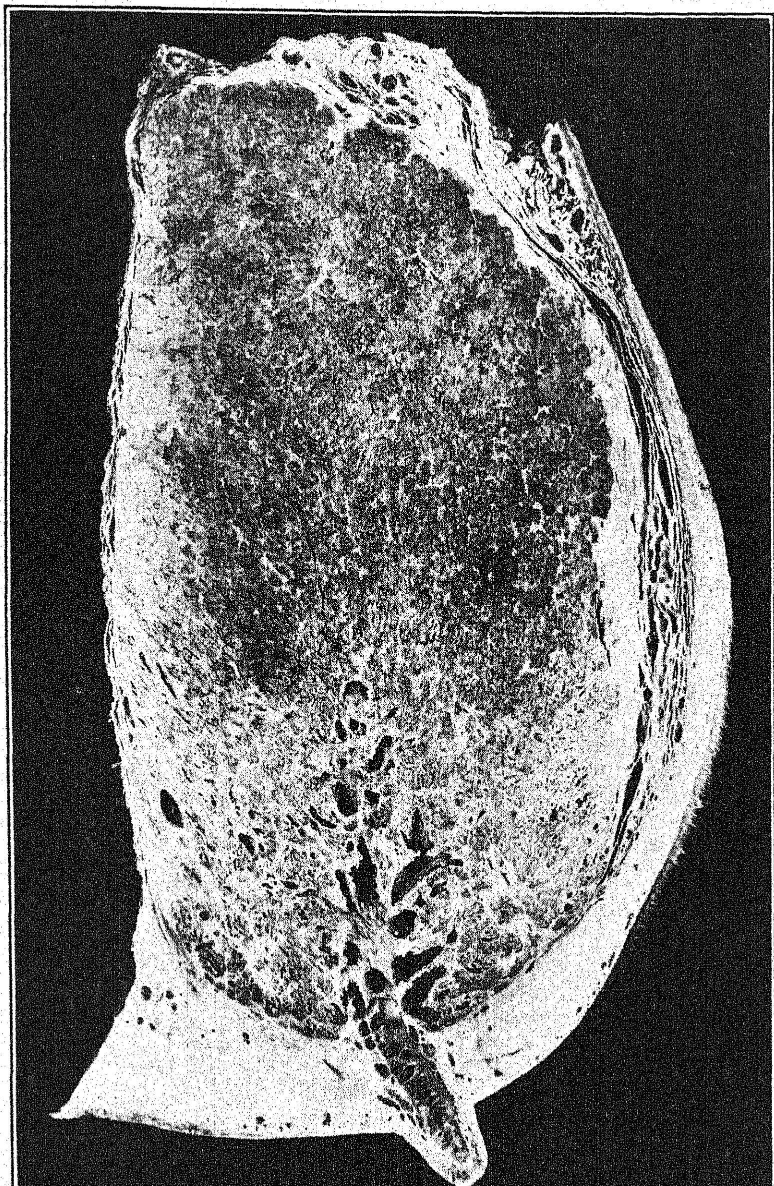

FIG. 3. Gross structure of udder tissue in vertical transverse plane through the rear teat, showing thick layer of edematous swelling along the base between the gland tissue and the skin. Note how the teat appears to be shortened.

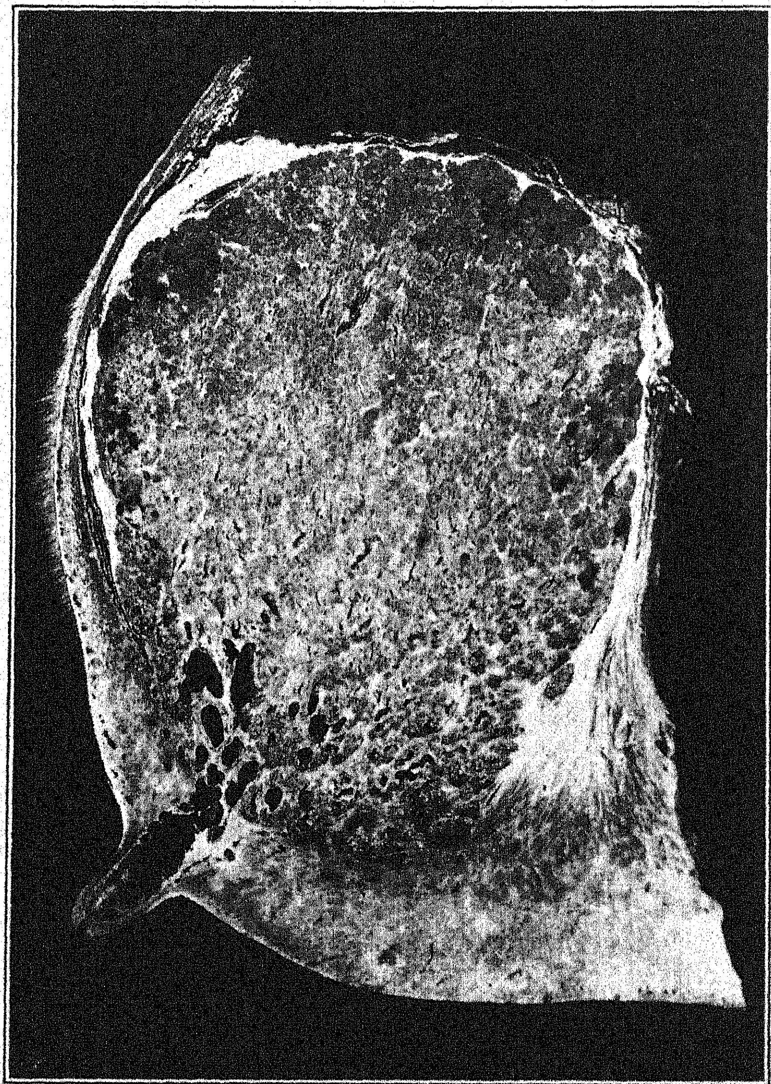

FIG. 4. Gross structure of udder tissue in a vertical transverse plane through a front teat. Although this surface was photographed more than 12 months after the udder was sectioned, the appearance is essentially unchanged.

Although the appearance of areas A and C which were taken from locations only a short distance above the front and rear teats differs somewhat from area B, which was located not far from the abdominal attachment of the front quarter where the tissue might be expected to be more actively secreting, these areas are entirely different in structure from area D which was taken from the edematous tissue. Apparently the edematous swelling does not invade the glandular tissue to any appreciable extent but is confined chiefly to the space between the mammary gland and the skin.

A part of the routine that is followed in connection with the post-mortem studies of the cow udders at the Beltsville Station involves a number of tests of the tissue after it has been filled with formalin, frozen, and cut into gross sections approximately one inch in thickness. Discs having an area of 6.25 square inches, are cut from certain gross sections at definite locations. Among the several determinations made are tests of the sponginess of the tissue of different udders and of the tissue from different parts of the same udder. The discs are soaked in water under vacuum, weighed, subjected to a pressure of 312.5 pounds to eliminate most of the water and weighed again. They are then resoaked as before and reweighed after which the degree of recovery and the amount of fluid taken up and held by the tissues per unit of pressed weight are determined.

After pressing and resoaking the weight of the discs taken from the glandular tissues of the udder from cow 848, averaged 97.7 per cent and those from the edematous tissue averaged 96.6 per cent of the soaked weight before the pressure was applied, indicating a very high recovery. The edematous tissue, however, was decidedly more spongy than the glandular tissue of this udder as it took up a quantity of water equal to 4.41 times its pressed weight as compared with an average of 1.91 times its pressed weight for the glandular tissue from a number of different locations. The pressed edematous tissue was particularly dry in appearance and seemed to consist almost entirely of loosely connected sheets or layers of light colored connective tissue running nearly parallel to each other. Air-dried edematous tissue was found to be only 41 per cent as heavy as air-dried glandular tissue. The air-dried weight was only 7 per cent of the weight before pressing for the edematous as compared with 16 per cent for the glandular tissue.

There has long been a question as to whether or not intense swelling of the udder at calving time is objectionable. Observations of A. G. Van Horn, Superintendent at the Woodward, Oklahoma, Station of the Bureau of Dairy Industry, indicate that the daughters of one sire used at that Station were particularly subject to intense and persistent swelling and that the swelling prevented a number of animals from reaching their maximum producing ability. Apparently the swelling described by Van Horn was edematous in character and similar to the condition described in connection with cow No. 848. Frequently it was accompanied by abdominal swelling, especially in

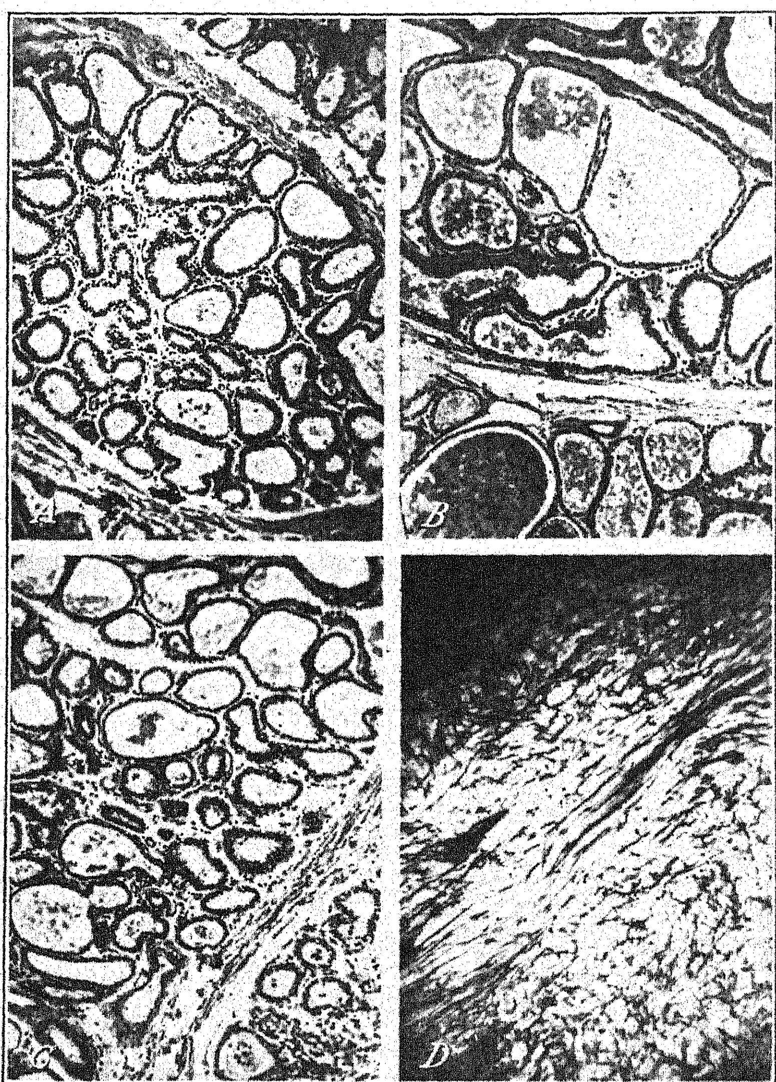

FIG. 5. Photomicrographs of mammary gland and edematous tissue: A, gland tissue from lower portion of front quarter; B, gland tissue from upper portion of front quarter; C, gland tissue from lower portion of rear quarter; D, edematous tissue.

young cows. It was reported that the swelling remained longest in the poorest attached udders.

As previously indicated cow No. 848 habitually showed edematous swelling at each parturition. Photographs taken 5 days before second calving, 7 days after third calving and 1 day after fourth calving give some idea of the extent to which it occurred. The one taken before second calving shows not

only considerable udder swelling but a definite abdominal swelling in the region of the navel. (Fig. 2.)

In production, cow No. 848 was somewhat erratic. During the first lactation which commenced at 2 years 1 mo., she reacted to the agglutination test (Bang's disease) and was moved to other quarters but was continued on the same schedule of feeding and milking and did not appear to suffer any marked reduction in milk flow. Her production, however, was low—never going above 42.5 pounds on any day—and amounted to only 5698 pounds of milk and 187 pounds of butterfat in 365 days. Calving again at 3 years 3 mos. of age she reached a high point of 80.2 pounds of milk in one day and produced a total of 11,695 pounds of milk and 377 pounds of butterfat in 323 days. In her third lactation, at 4 years 5 months, her highest production for a single day was 74.0 pounds of milk and her total for 365 days was 15,200 pounds of milk and 520 pounds of butterfat.

Routine studies of the rate of milking with a milking machine indicated that she was a slow milker. Timing studies were carried on during the first, second and third lactations. At the first 2-day timing, 121 days after first calving she was producing an average of 22.8 pounds of milk daily. The time required for milking was 8.35 minutes, 31.4 per cent of which was spent in massaging, and 20.8 per cent of the total yield of milk was obtained during the massaging period. At the second 2-day timing, which occurred 119 days after second calving, her average production was 42.25 pounds of milk daily, the time required for milking was 9.75 minutes of which 31.2 per cent was spent in massaging the udder, and 38.3 per cent of the total yield was obtained during the massaging period. The third timing occurred 49 days after third calving, when she was producing an average of 71.75 pounds of milk daily. This time 13.10 minutes was required for milking. Only 2.8 per cent of that time was spent in massaging and the massaging yielded only 0.6 per cent of the total quantity of milk.

CONCLUSIONS

Aside from the edematous swelling there was nothing about the appearance of the udder of cow No. 848 at any time to indicate any significant abnormality and all four quarters of the udder were functioning at the time of slaughter. The point that stands out as of particular interest is the fact that the intense swelling, which occurred in the udder of this cow at calving time apparently was edematous in nature, and that it did not appear to invade or affect the secreting tissue to any appreciable extent, but on the contrary was confined chiefly to the space between the glandular tissue and the skin.

THE BREEDING EFFICIENCY OF PROVED (AGED) SIRES

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How many years of usefulness can be expected from a dairy sire that is 5 years of age or older? How frequently can such a sire be used successfully? Do seasonal changes have any effect on the breeding efficiency or fertility of aged sires? What effect if any does moving, and the subsequent change in environment, have on the usefulness of an old sire?

The Bureau of Dairy Industry has not only used proved sires in its various experimental station herds for a number of years, but it has probably used more proved sires than any other institution. Recognizing that the records of these sires might disclose some information with which to answer these questions, the author has analyzed the service records of 20 proved sires used in the station herds. The results of the study are reported in the following pages.

SOURCE AND NATURE OF THE DATA STUDIED

The data for this study were collected from the breeding records of the Bureau's experimental herds at Jeanerette, La., Lewisburg, Tenn., Hannibal, Mo.,[1] Columbia, S. C.,[1] Huntley, Mont., Mandan, N. Dak., Woodward, Okla.,[1] and Ardmore, S. D.[2]

The study includes the breeding records of 20 proved sires for which the data were complete and known to be accurate. Other proved sires were used to a limited extent in these herds, or for short periods, and they will be referred to in the discussion.

The data do not afford a comparison between young and old sires because very few young sires have been used and only for short periods. Neither was it possible to determine the breeding condition of the females in these herds, except in a general way. All the herds were managed by experienced men, most of whom were capable of treating ordinary breeding troubles. Veterinarians were employed for the most difficult cases, and it is believed that breeding trouble with females was no more serious in these herds than in the average breeding herd. The herds were subjected periodically to tests for Bang's disease. There was an occasional female reactor in some of the herds. None of the bulls included ever reacted to the Bang's test.

In this study, the breeding efficiency or fertility of a sire, as indicated by the number of services per conception when the sires were mated to fertile females, is expressed both by ratios and by percentages.

Received for publication May 17, 1938.

[1] Dairy work at these stations is in cooperation with State agricultural experiment stations.

[2] Dairy work at this station was discontinued in 1932.

The data were tabulated and arranged to show breeding efficiency or fertility, by months, by years, and by ages, for the 20 sires during the time they remained fertile and in service in the station herds. The services to all cows include those to fertile cows, sterile cows, and to cows in which pregnancy was doubtful, and are of interest in showing whether there is any relation between frequency of service and breeding efficiency.

For the purpose of this study a female was considered fertile up to the time of her last conception, no matter how many times she was bred for her last conception or to how many sires. All services to a cow, after her last conception, were credited to the bulls as services to a sterile female unless it was definitely known that the cow was pregnant.

In a few cases, sires were continued in service for some time after they became sterile because the fact that they were sterile was not evident at the time. All services credited to a sire, after he got his last conception are omitted from the comparative study. Only services occurring after a sire was 5 years of age are included in the tabulation.

Sires Studied

For convenience in presenting the data, the 20 sires have been numbered from 1 to 20. Table 1 gives the breed of each sire, his age when he began service in the station herd, his age when his use was actually discontinued, his age when he was judged infertile, and the length of his fertile service in the station herd.

The 20 sires include 8 Jerseys, 2 Guernseys, and 10 Holsteins. With the exception of sires 9, 11 and 14, all these bulls were proved sires when they began service in these station herds, and they varied from 5 to 10 years of age at the time. Sires 9, 11 and 14 were started in service as young unproved bulls, but were proved later.

FEEDING AND MANAGEMENT OF THE BULLS

All the bulls had been moved to the station at which they were used shortly before the start of their service. Bulls 3, 5 and 6 were moved rather short distances by truck, but the others were shipped several hundred miles by train. This movement was necessarily accompanied in most cases by abrupt changes in environmental and climatic conditions.

Attention is directed to the wide range of climatic conditions at the stations where these bulls were in service, as this may have a bearing on some of the points discussed later.

All the bulls were kept in strong pens and were allowed to run in or out of a shed at will. The rations varied somewhat according to the station. A good quality of legume hay was fed, but was given in limited amounts if the bull was inclined to develop a large middle. Grain, usually the mixture fed to the regular herd, was fed in sufficient amounts to keep the bulls in

TABLE 1

Age of the 20 sires when they started service in the Bureau's station herds, age when their use was discontinued, age when they were judged infertile, and the length of their fertile service in these herds after they were 5 years old or older

Sire No.	Breed	Age when service began in these herds	Age when use was discontinued	Age when sire was judged infertile	Length of fertile service in the herd, after 5 years of age	Station where sire was used
		Yr.–Mo.	*Yr.–Mo.*	*Yr.–Mo.*	*Yr.–Mo.*	
1	Jersey	5–11	10–9	10–9	4–10	Jeanerette, La.
2	Jersey	8–3	13–5	13–3	5–0	Jeanerette, La.
3	Jersey	7–1	(1)	(1)	(1)	Hannibal, Mo.
4	Jersey	10–5	15–2	14–6	4–1	Lewisburg, Tenn.
5	Guernsey	10–3	13–3	13–3	3–0	Columbia, S. C.
6	Guernsey	7–3	13–10	12–0	4–9	Columbia, S. C.
7	Holstein	6–10	12–3	12–3	5–5	Huntley, Mont.
8	Holstein	5–5	10–7	(2)	5–2	Mandan, N. Dak.
9	Holstein	4–4	8–0	(2)	3–0	Huntley, Mont.
10	Holstein	6–2	11–4	11–2	5–0	Mandan, N. Dak., and Huntley, Mont.
11	Holstein	1–5	6–10	(2)	1–10	Woodward, Okla.
12	Holstein	6–0	12–5	12–5	6–5	Woodward, Okla.
13	Holstein	5–4	9–11	(2)	4–7	Woodward, Okla.
14	Holstein	3–8	16–1	16–1	11–1	Huntley, Mont., and Ardmore, S. D.
15	Jersey	7–2	8–9	8–9	1–7	Jeanerette, La.
16	Jersey	7–9	10–0	10–0	2–3	Jeanerette, La.
17	Jersey	7–9	9–10	9–10	2–1	Jeanerette, La.
18	Jersey	7–11	12–0	12–0	4–1	Jeanerette, La.
19	Holstein	6–8	(1)	(1)	(1)	Woodward, Okla.
20	Holstein	6–11	(1)	(1)	(1)	Mandan, N. Dak.
Average		6–8	10–10[3]	12–0[4]	4–5[3]	

[1] Still fertile and in active service as of May 31, 1937.
[2] Fertile when disposed of.
[3] Average for 17 sires.
[4] Average for 13 sires.

fair condition. Silage was fed sparingly. The bulls were encouraged to exercise but no systematic plan of exercising was followed.

FEEDING AND MANAGEMENT OF THE COWS

The females in the various herds where the bulls were in service were fed and managed under desirable conditions. All cows on official test were given a good grade of legume hay and silage, and a grain mixture. As a rule, the cows on test received no pasture. The regular herd cows were fed legume hay, silage, and a limited-grain ration, and pasture. Many of the cows were in feeding experiments in which they received only roughage of good quality. Studies by the Bureau indicate that this practice does not affect the fertility or breeding condition of cows.[3] Pasturage at the stations varied in kind and quality, with the region and climatic conditions.

[3] Graves, R. R., and Dawson, J. R. Feeding Dairy Cows on Alfalfa Hay Alone. U. S. Dept. Agr. Tech. Bul. 610, 1938.

When cows were on test they were bred approximately 5 months after calving, whereas cows in the regular herd were bred 2 to 3 months after calving. Heifers were bred for the first time at approximately 15 months of age.

RESULTS AND DISCUSSION

Length of Fertile Service in the Herds

According to the data in Table 1, the 20 sires were started in service in these herds at the average age of 6 years 8 months. Eliminating sires 9 and 11, which were started in service as young bulls, the average age that the remaining 18 sires were started in service was 7 years, 1 month. Three of the sires are still in service and the average age of the other 17 was 10 years 10 months when their use was discontinued. Thirteen of the 20 sires died or were infertile at the time they were disposed of at an average age of 12 years. The average period of fertile service for sires in these herds was 4 years 5 months for services after the age of 5 years. Only 17 of the 20 sires were included in this average since sires 3, 19, and 20 are still in service.

In addition to the sires shown in Table 1, other proved sires were used in the station herds. Seven of these were victims of injury or disease after a short period of service, and two were frequently shifted from one herd to another so that the breeding data on these sires are not considered suitable to use in this study. The shortest period of service by any of the 29 sires was 8 months and the longest period of fertile service was 11 years 1 month by sire 14, not including his services prior to 5 years of age.

Sire 14 was fertile up to the time of his death at 16 years 1 month of age. A sire in the Bureau's herd at Beltsville, Md., was fertile to the age of 16 years 4 months. A sire in South Carolina[4] is reported as being in service and fertile at 17 years 1 month of age.

Fertility of the Sires

Table 2 shows the number of services to all cows, by each sire during the time he was used in the station herd, also the number of services to fertile cows only, and the number of conceptions obtained. The fertility of the sire is represented by the percentage of services to fertile cows that resulted in conceptions.

The 20 sires had a total of 3,585 services to all cows, of which 2,982 were to fertile cows. The total number of conceptions was 1,197. This is a ratio of 2.49 per conception, based on services to fertile cows.

The 20 sires varied in fertility, from a low of 21 per cent for sire 4 to a high of 71 per cent for sire 16. The average for the 20 sires was 40 per cent, and 10 of the sires were below the average for the group.

[4] Fern's Raider of Appin 64700, a Guernsey sire owned by C. S. McCall, Bennettsville, S. C. Information to the author through J. P. LaMaster, Clemson College, S. C.

TABLE 2

The relative fertility or breeding efficiency of the 20 sires during the time they were used in the station herds

(Only services after 5 years of age are included)

Sire no.	Services to all cows	Services to fertile cows	Conceptions	Breeding efficiency,[1] or fertility
	No.	*No.*	*No.*	*Per cent*
1	326	254	78	31
2	121	72	19	26
3	160	144	58	40
4	267	235	50	21
5	135	120	35	29
6	147	133	49	37
7	181	170	57	34
8	141	117	72	62
9	142	126	41	33
10	397	356	144	41
11	87	63	29	46
12	196	166	109	66
13	166	146	96	66
14	159	145	72	50
15	97	65	23	35
16	58	44	31	71
17	98	71	40	56
18	292	211	47	22
19	251	209	53	25
20	164	135	94	70
Total	3,585	2,982	1,197	......
Average	179	149	60	40

[1] Based on the number of services to fertile cows that resulted in conceptions.

Miller and Graves[5] reported the breeding records of 10 mature bulls and 18 young bulls used at the Beltsville, Md., station. The 10 mature bulls had 1,109 services to fertile females and got 289 conceptions, a ratio of 3.83 services per conception.

The ratios of services per conception, both in this study and in the Beltsville report, seem very high. The herds all have had breeding trouble at one time or another, as a result of infections of various kinds. These high ratios are undoubtedly due in part to the use of older sires and also to the fact that sterile cows are held longer in these herds, in an effort to get them to breed, than would be the case in most herds.

Effect of Age on Fertility

Table 3 gives the number of services to fertile cows, the number of conceptions, and percentage of services that resulted in conceptions, for the 20 sires according to age by 6-month periods starting at 5 years of age.

[5] Miller, Fred W., and Graves, R. R. Reproduction and Health Records of the Beltsville herd of the Bureau of Dairy Industry. U. S. Dept. Agr. Tech. Bul. 321. 1932.

TABLE 3

The effect of advancing age on fertility of sires

Age	Sires included	Services to fertile cows	Conceptions	Fertility[1]
Years	*No.*	*No.*	*No.*	*Per cent*
6-month period				
5 to 5½	5	46	24	52.2
5½ to 6	6	67	33	49.3
6 to 6½	8	100	52	52.0
6½ to 7	10	132	69	52.3
7 to 7½	12	220	89	40.5
7½ to 8	14	256	115	44.9
8 to 8½	14	256	121	47.3
8½ to 9	15	325	144	44.3
9 to 9½	15	324	131	40.4
9½ to 10	14	325	122	37.5
10 to 10½	13	219	74	33.8
10½ to 11	13	225	57	25.3
11 to 11½	10	122	49	40.2
11½ to 12	8	83	31	37.3
12 to 12½	7	64	20	31.3
12½ to 13	3	47	19	40.4
13 to 13½	4	89	20	22.5
13½ to 14	2	31	12	38.7
14 to 14½	2	31	8	25.8
14½ to 15	2	8	5	62.5
15 to 15½	......	......	......	......
15½ to 16	1	9	3	33.3
16 to 16½	1	3	1	33.3
2-year periods				
5 to 7	11	345	178	51.9
7 to 9	16	1057	469	44.4
9 to 11	18	1093	384	35.1
11 to 13	9	316	119	37.7
13 and over	4	159	45	28.3

[1] Based on number of services to fertile cows that resulted in conceptions.

It is of interest to mention the extreme variation in fertility of the individual sires as age advanced. Sire 1, as one example, was 100 per cent fertile at the age of 5½ to 6 years, and his fertility dropped to 70 per cent during the following 6-month period. At the age of 6½ to 7 years, however, he got only 1 conception in 15 services to fertile cows, indicating a fertility of only 6.7 per cent. His fertility reached 51.9 per cent at the age of 8 to 8½ years, then dropped sharply to 19.1 per cent. During the 6-month period of his heaviest service, from 9½ to 10 years, his fertility was 32.6 per cent, when he got 15 conceptions out of 46 services. For the next 6-month period he got only 1 conception out of 34 services, indicating a fertility of only 2.9 per cent.

Sires 8, 12, 13, 16, and 20 for the most part had a high fertility throughout the years they were used.

Sire 14 remained fertile to the oldest age of any of the 20 sires. While there were a few periods when his fertility was low, he showed a high degree of fertility throughout most of his life and up to the time of his death at 16 years 1 month of age.

Table 3 also shows the relation of fertility to advancing age, by 2-year age periods. At 5 to 7 years of age, the fertility of the group was 51.9 per cent, decreasing to 44.4 per cent at 7 to 9 years of age, 35.1 per cent at 9 to 11 years of age, slightly increasing to 37.7 per cent at 11 to 13 years of age; with a further steady decrease to 28.3 per cent for services after 13 years of age. On the average there was a decided and consistent decline in fertility with advancing age, but the breeding records of the individual sires indicate that there is great variation in this respect and that conclusions based on averages should be carefully considered.

TABLE 4

The effect of frequency of service on fertility

Frequency of service (Services per sire per month)	Services to all cows				Services to fertile cows only			
	Number of sires included	Services	Conceptions		Number of sires included	Services	Conceptions	
No.	*No.*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*No.*	*Per cent*
1	20	156	63	40.4	19	169	97	57.4
2	19	326	135	41.4	20	340	160	47.1
3	19	360	137	38.0	20	363	155	42.7
4	20	408	130	31.9	19	420	161	38.0
5	19	495	166	33.5	20	395	158	40.0
6	18	330	132	40.0	17	324	149	46.0
7	17	329	109	33.1	17	240	92	38.3
8	15	296	89	30.1	11	248	60	24.2
9	15	315	78	24.8	8	171	62	36.3
10	5	110	28	25.5	3	40	11	27.5
11	9	132	39	29.5	6	88	32	36.3
12	5	84	19	22.6	2	36	12	33.3
13	4	52	28	53.8	2	26	16	49.5
14	2	28	9	32.2	2	42	11	26.2
15	3	90	18	20.0	3	45	17	37.8
16	2	32	13	40.6	1	16	2	18.8
17	......	......	......	....	......	......	......	....
18	......	......	......	....	......	......	......	....
19	1	19	2	10.5	1	19	2	10.5
20	......	......	......	....	......	......	......	....
21	......	......	......	....	......	......	......	....
22	......	......	......	....	......	......	......	....
23	1	23	2	8.7	......	......	......	....
1 to 3, inc.	20	842	335	39.8	20	872	412	47.2
4 to 6, inc.	20	1233	428	34.7	20	1139	468	41.1
7 to 9, inc.	20	940	276	29.4	20	659	214	31.0
10 or more..	14	570	158	27.7	8	312	103	33.0

Effect of Frequency of Service on Fertility

What effect does frequency of service have on the fertility of old sires?

Table 4 shows the number of services, to all cows and to fertile cows, the number of conceptions, and the fertility of the 20 sires, arranged according to the number of services per calendar month. Considering services to fertile cows only, the trend was decidedly toward a lower fertility as the number of services increased from 1 to 8 per month. As the number increased beyond 8, there did not appear to be any further decline in fertility. However, many of the sires showed just as high or higher fertility when used from 7 to 15 times a month as they did when used only once a month.

It is probable that the most pronounced effect of frequency of service on fertility will not be felt until a time following the period of service. With this point in mind, the data were tabulated by months and by sires according to the number of total services that particular sire had had during the preceding month. Table 5 gives the results of this tabulation.

TABLE 5

The effect of frequency of service in one month on the fertility of the sires during the following month

Services during preceding month	Number of sires included	Services to fertile cows, conceptions, and fertility for the following month		
		Services	Conceptions	
No.	*No.*	*No.*	*No.*	*Per cent*
No services	16	91	43	47.3
1 to 3, inclusive	20	949	423	44.6
4 to 6, inclusive	19	896	365	40.7
7 to 9, inclusive	18	666	230	34.5
10 and over	12	304	90	29.6

Sixteen sires had 91 services and secured 43 conceptions, indicating 47.3 per cent fertility, during months that followed months when no services were permitted. When 1 to 3 services were permitted per month, the fertility for the following month was 44.6 per cent. The decline in fertility on this basis of interpretation is rather rapid and consistent. When 10 or more services were permitted in one month, the fertility for the following month was 29.6 per cent. It would appear that a rest period of a month is of distinct benefit, and that as the number of services per month increases to 10 or more there is a decided and consistent drop in fertility the following month. Here again, however, was found great variation between individual sires.

It is a matter of interest to note that 24 per cent of all services to the 20 sires studied were at the rate of 1 to 3 per month; 35 per cent were at the rate of 4 to 6 per month; 26 per cent were at the rate of 7 to 9 per month; while only 16 per cent of all services were at the rate of 10 or more per month. One sire was used 23 times, during one month, and another sire was used 19 times.

Effect of Season on Fertility

Are old bulls more fertile at some seasons of the year than at others? Table 6 shows the number of services to all cows and to fertile cows, the conceptions, and the fertility of the 20 sires according to the month of the year in which the services were performed.

TABLE 6

The effect of season on fertility of sires

Month in which services occurred	Services to all cows	Services to fertile cows only	Conceptions	Breeding efficiency or fertility[1]
	No.	*No.*	*No.*	*Per cent*
January	291	235	94	40.0
February	263	227	97	42.7
March	311	262	107	40.8
April	323	262	116	44.3
May	340	279	110	39.4
June	281	237	90	38.0
July	310	266	115	43.2
August	281	233	94	40.3
September	251	205	80	39.0
October	313	261	108	41.4
November	307	262	85	32.4
December	314	253	101	39.9

[1] Based on services to fertile cows that resulted in conceptions.

There is a tendency for the fertility to be somewhat higher during the months of February, April, July, and October, when the fertility (based on services to fertile cows) averaged 42.9 per cent. The low trends come in June, September, and November, during which months the average fertility was 36.5 per cent. This difference of 6 per cent is probably of little significance, however, when one considers the wide range of climatic conditions obtaining at the stations where the sires were used (see Figure 1).

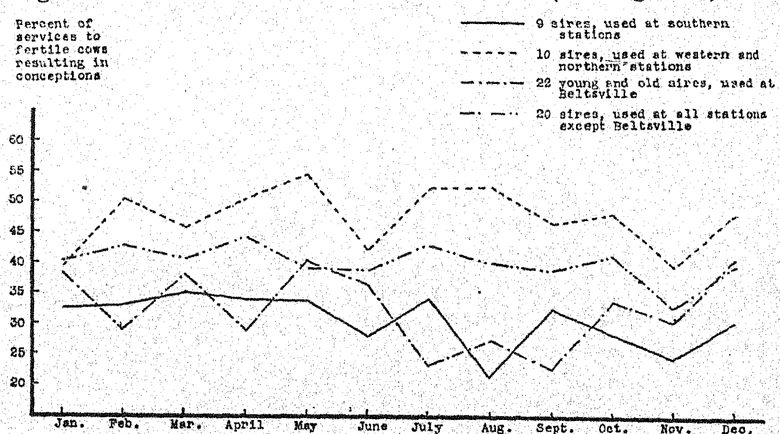

FIG. 1. Effect of season of the year on fertility of sires.

Miller and Graves,[6] in a study of 22 young and old bulls used only at the Beltsville, Md., station covering a period of 4 years and including 1,539 services to fertile cows, found the lowest fertility (23 per cent) in July and September, after which the fertility increased during the fall and winter months (see Figure 1). They suggested that the hot weather influences the functioning of the genital organs adversely and that increased genital efficiency seems to have been associated with the advent of autumn. This apparently was not the case when all of the 20 bulls included in this study are considered.

Because of the wide range of climatic conditions at the several stations, 19 of the sires were divided into two groups according to whether they were in service at a southern station or at western and northern stations. Nine sires (1, 2, 4, 5, 6, 15, 16, 17, and 18) were placed in the southern group, and 10 sires (7, 8, 9, 10, 11, 12, 13, 14, 19, and 20) in the western and northern group.

The fertility curves for the two groups follow the same general trend (see Figure 1), but the curve for the southern group follows that of the Beltsville group more closely than does the curve of the western and northern group. Climatic conditions at Beltsville are also more similar to those of the southern group of stations.

It is of further interest to note the decidedly lower range in fertility of the sires used at the southern stations as compared to those used at the western and northern stations. Those used at the southern stations had an average fertility of 36 per cent, while those used at the western and northern stations averaged 49 per cent. Higher temperatures during the summer with higher humidity generally prevail at the southern stations. At the western and northern stations during the summer the temperature rises quite high, but as a rule drops sharply at night. Lower humidity prevails at the western and northern stations than at the southern stations.

Effect of Moving on Fertility

Does the moving of sires for a considerable distance with the accompanying change in environmental conditions lower the fertility of old bulls and, if so, how long does this condition last?

Only 17 of the 20 sires are considered suitable for this phase of the study, because they were transported for considerable distances before their services as proved sires in the station herds began. Unfortunately, there is no accurate record of the fertility of most of them before they were moved. Table 7 shows the approximate distance in miles that the sires were transported, and the fertility by 3-month periods for 2 years following their initial service in the herds.

[6] *Loc. cit.*

TABLE 7

The effect of shipment and changes in environment on the fertility of 17 sires, as indicated at stated periods during the first and second year after arrival at the respective stations[1]

Sire number	Distance moved	Fertility of sires during first year											
		1 to 3 months			4 to 6 months			7 to 9 months			10 to 12 months		
		Services	Conceptions		Services	Conceptions		Services	Conceptions		Services	Conceptions	
	Miles	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
1	1,100	8	8	100.0	4	1	25.0	2	1	50.0	8	.0	00.0
2	200	10	3	30.0	5	4	80.0	8	4	50.0	6	2	33.3
3	125	8	4	50.0	11	4	36.4	11	5	45.5	13	6	46.2
4	630	30	8	26.7	30	6	20.0	14	3	21.4	16	2	12.5
5	85	7	0	0.0	9	1	11.1	15	2	13.3	6	3	50.0
7	685	3	0	0.0	6	1	16.7	7	1	14.3	19	5	26.3
8	370	2	1	50.0	3	1	33.3	1	0	0.0	7	4	57.1
10	370	13	7	53.8	17	3	17.6	17	8	47.1	22	8	36.4
12	815	8	6	75.0	13	7	53.8	11	9	81.8	2	0	00.0
13	600	3	2	66.7	10	6	60.0	12	7	58.3	10	5	50.0
14	300	4	3	75.0	6	4	66.7	2	2	100.0	......	......	......
15	1,100	2	1	50.0	10	4	40.0	15	3	20.0	11	2	18.2
16	835	1	1	100.0	5	2	40.0	......	......	......	2	2	100.0
17	1,100	6	4	66.7	2	2	100.0	11	7	63.6	18	9	50.0
18	1,785	17	1	5.9	14	3	21.4	9	1	11.1	11	3	27.3
19	815	21	3	14.2	22	4	18.2	10	4	40.0	33	3	9.1
20	370	14	13	92.9	5	5	100.0	7	4	57.1	11	8	72.7
Total	......	157	65	41.4	172	58	33.7	152	61	40.1	195	62	31.8

[1] All sires were transported in freight cars, except Nos. 3, 5, and 6, which were moved by truck.

TABLE 7—(*Continued*)

Sire number	Distance moved	Fertility of sires during second year											
		13 to 15 months			16 to 18 months			19 to 21 months			22 to 24 months		
		Services	Conceptions		Services	Conceptions		Services	Conceptions		Services	Conceptions	
	Miles	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
1	1,100	22	8	36.4	14	6	42.9	6	0	00.0	9	5	55.5
2	200	3	0	00.0	11	1	9.1	13	3	23.1	1	0	00.0
3	125	9	3	33.3	12	3	25.0	10	5	50.0	12	5	41.7
4	630	14	1	7.1	8	5	62.5	4	2	50.0	5	1	20.0
5	85	2	2	100.0	8	1	12.5	14	5	35.7	12	4	33.3
7	685	17	9	52.9	8	5	62.5	10	4	40.0	6	3	50.0
8	370	5	4	80.0	3	2	66.7	1	1	100.0	9	5	55.6
10	370	22	7	31.8	18	5	27.8	8	6	75.0	21	7	33.3
12	815	10	5	50.0	10	6	60.0	17	13	76.5	4	3	75.0
13	600	3	3	100.0	3	2	66.7	12	7	58.3	8	5	62.5
14	300	.....	.....	.....	6	2	33.4	9	4	44.4	3	2	66.7
15	1,100	17	7	41.2	6	4	66.7	4	2	50.0	.....	.....	.....
16	835	4	2	50.0	2	0	00.0	9	7	77.8	10	9	90.0
17	1,100	6	4	66.7	7	3	42.9	7	4	57.1	13	7	53.8
18	1,785	29	6	20.7	25	6	24.0	21	2	9.5	21	6	28.6
19	815	35	9	25.7	19	5	26.3	18	9	50.0	19	2	10.5
20	370	25	17	68.0	9	3	33.3	13	8	61.5	9	5	55.6
Total	.....	223	87	39.0	169	59	34.9	176	82	46.6	162	69	42.6

For the first 3 months following arrival at the stations the 17 sires had an average fertility of 41.4 per cent, which is remarkable because of the decline to 33.7 per cent at 4 to 6 months following arrival. The high average fertility immediately following shipment is unexplainable unless the time was too brief for the full effects of shipping and changes in environment to be exerted. Or possibly the change of environment may have had a temporary stimulating effect on fertility.

The lowest point in fertility (31.8 per cent) was 10 to 12 months after the bulls arrived, after which there was a decided trend toward higher fertility during the second 12 months of service in spite of the advancing age of the sires. The average fertility for the first year following movement of the sires was 36.4 per cent as compared to 40.7 per cent for the second year.

The individual sires offer interesting studies. Sire 1 showed 100 per cent fertility for the first 3 months following arrival, which was the highest for the 5 years he was used. He was moved 1,100 miles from Beltsville, Md., to Jeanerette, La., with a very decided change in climatic and other environmental conditions. Sires 5 and 7 got no conceptions for the first 3 months, but their fertility increased gradually from then on. Sire 5 was moved only 85 miles by truck, and there was practically no change in climatic conditions. While the average fertility is decidedly downward for the first year following movement of the sires and is decidedly upward for the second year, the individual variation is so wide that definite conclusions cannot be drawn.

SUMMARY AND CONCLUSIONS

Detailed service records of 20 proved sires used in 8 branch experiment station dairy herds are presented and the fertility of these sires after 5 years of age is expressed by the percentage of services to fertile cows that resulted in conceptions. Extra services and services to infertile cows are given separately. The data were tabulated and analyzed from the standpoint of (1) the relative fertility of the individual sires, (2) the effect of advancing age on fertility, (3) the effect of frequency of service on fertility, (4) the effect of season of the year on fertility, and (5) the effect of moving sires on their fertility.

Because of the extreme and inconsistent variation in fertility exhibited by individual sires on all phases included in this study, it is apparent that averages are of little value for application to individual sires.

SOFT CURD MILK*

A Critical Review of the Literature

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When milk from individual cows is coagulated with rennin and (or) pepsin, the toughness and adhesiveness of the coagulum varies widely with different animals. Some milk forms a soft, friable type of curd which might be described as "mushy." Other milk exhibits an extremely tough rubbery curd mass which fractures with difficulty. Milk with the former character of coagulum has come to be known as soft curd milk while that with the latter type of coagulum is known as hard curd milk.

The interest in soft curd milk has been increasing steadily since 1923 when Hill (35) proposed his test for determinating the curd character of milk as an index to its suitability for infant feeding. Previous to this time Washburn and Bigelow (81), Washburn and Jones (82), Buckley (9) and Alleman and Schmid (1) had pointed out marked differences in the coagula obtained with different milks when treated with digestive enzymes but, with the exception of Alleman and Schmid, none of these workers developed a means of accurately classifying the curd characteristics and their work was largely overlooked.

As early as 1913 Brennemann (6) explained the favorable results obtained with boiled milk in infant feeding on a curd character basis and intimated that other successful modifications of cow's milk for infant use depend primarily on the ability of the modifier to alter the physical properties of the coagulum (particularly the particle size) formed in the stomach after ingestion.

The interest of the milk distributors in soft curd milk has grown tremendously in the past few years and due to the fact that the use of evaporated milk in infant feeding has been increasing rapidly (largely at the expense of fluid milk), it is their desire to place on the market a fresh milk having digestion characteristics as suitable for infants as has the canned variety. They have been more interested in the subject since it has been found possible to modify or soften the curd character of average mixed milk by processing rather than having to resort to a selection of individual cows giving milk with the desirable characteristics, as originally suggested by Hill (36, 37, 39) and as practiced by dealers in several cities where soft curd milk has been sold for the past 10 years.

That the medical profession is alert to the possibilities of soft curd milk is evidenced by the approval of "Soft Curd Certified Milk" by the Amer-

* Authorized for publication on September 6, 1938, as Paper No. 848 in the Journal series of the Pennsylvania Agricultural Experiment Station.

ican Association of Medical Milk Commissions and its endorsement by physicians and pediatricians in many places; also by the recent action of the Council on Foods of the A. M. A. in publishing a report concerning the nutritional significance of the curd tension of milk (18).

The purpose of this article is to review the subject of soft curd milk, to summarize the available information and to criticise it in a constructive manner.

THE CURD TEST

Hill's original test (35) for measuring the curd tension or curd toughness of milk has been criticised and modified by a number of workers (10, 15, 48, 58, 59) as well as by himself (9). Recently a committee of the American Dairy Science Association, after two years of study, has attempted to standardize the determination by reporting a tentative method (19). Briefly, this method substitutes N/10 hydrochloric acid, containing 0.45 per cent pepsin for the calcium chloride pepsin reagent originally used; adds tempered milk to the tempered coagulant in a 250 ml. beaker or 8 oz. mayonnaise jar; establishes 95° F. ± 1° F. as the coagulation temperature and 10 minutes as the coagulation interval; requires the addition of the 100 ml. charge of milk to the 10 ml. of reagent by means of a 100 ml. pipette with the tip removed so that it drains water in 4½ seconds, the milk to be added holding the pipette vertically over the center of the receptacle and blowing it into the coagulant in approximately 2 seconds with no further agitation; requires a knife of similar design to that used in the American Curd-O-meter with the same linear cutting surface; specifies that any accurate instrument may be used which embodies an automatic movement either of the knife or receptacle, provided that the rate be approximately one inch in five seconds; and demands that the result be the average of two or more maximum readings checking within 10 per cent. If the test is carried out as described the pH of the whey from the cut samples will be between 5.95 and 6.10 depending on the buffer capacity of the milk.

It is the hope of the committee that this tentative method will eliminate the diversity of procedures in use the last few years and make for uniformity. Undoubtedly some of the discrepancies in the literature are due to the wide differences in methods used.

The curd tension instrument in use to the greatest extent at present is the American Curd-O-meter made by Heusser Instrument Company of Salt Lake City. This equipment has been found satisfactory if an automatic method of raising the curd receptacle against the knife is provided. The simplest means of accomplishing this is through the use of a small hydraulic lift which can be constructed easily by any sheet metal worker.

In 1936 the Submarine Signal Company, of Boston, developed an instrument with a knife similar to that employed by the Curd-O-meter except that it is suspended from a gauge floating in a column of mercury and moves

downward through the curd at an even rate, actuated by a motor. When properly used this instrument and the Curd-O-meter give closely agreeing results.

Within the last year, Chambers and Wolman (14, 87) have described a method of determining curd particle size when milk is coagulated in "artificial stomachs" under conditions arranged to simulate those in vivo. Their method calculates the curd surface of the coagulated milk as an index to its digestibility. This method, providing the conditions are what they should be, would seem to offer a more accurate gauge of the digestion characteristics of milk than curd tension, since the rate of gastric digestion and the rate of stomach clearance appear to be related to curd surface area (7, 22) or curd particle size (6, 26) rather than to curd toughness as such. More study is needed before this idea is accepted and perhaps some modifications and simplifications of the suggested technique would be desirable before the method is offered as being superior to that of curd tension. Chambers and Wolman find a general relationship between their "curd numbers" and curd tension as determined by the original Hill method. There are, however, some rather wide discrepancies in the case of certain modified milks.

NATURAL SOFT CURD MILK

Composition and Properties.—Normal, individual, cow's milk will vary in curd tension from about 15 grams to about 150 grams by the Hill method. Using the tentative method (19) or Miller's procedure (58), the range will be wider, soft curd milk giving about the same results but hard curd milk showing higher values (24, 58). While Hill originally suggested an upper limit of 20 grams (37) for soft curd milk, at present by common consent, milk with a tension under 30 grams (in a few cases 33 grams) is considered as soft curd.

Natural soft curd milk is found in all breeds of dairy cattle but predominates in the Holsteins, followed in order by the Ayrshires, Brown Swiss, Guernseys and Jerseys (2, 5, 22, 37, 39, 66). It is invariably low in total solids, solids-not-fat (particularly casein), fat, and probably ash (22, 26, 38, 59, 60, 83). Several studies have failed to indicate that there is any inherent qualitative difference between soft curd milk and hard curd milk or between the respective ingredient substances, the work of Weisberg *et al.* (83) being outstanding. It appears, therefore, that soft curd milk is not a different kind of milk but merely a milk low in solids and of high water content. The ingredient of milk most closely related to curd tension is casein (2, 22, 83). Doan and Welch (22) assert that curd tension is a linear function of the casein content within the limits of error of the Hill test and the data of Anderson, *et al.* (2) are even more definite on this point. Because of its dilute composition, soft curd milk is lower than hard curd milk in titratable acidity (22), buffer capacity (22, 60, 83),

energy value (26, 60) calcium and phosphorus content (2, 22, 83) and its rate of coagulation with rennin is retarded (40, 71). There appears to be no significant difference between the two types of milk with respect to: pH (22, 60, 71, 83), flocculation point of casein (22, 83), freezing point (22, 83), surface tension (22), and relative viscosity of the whey (83). Whether the proportions of the three different casein fractions found in milk by Svedberg, Carpenter and Carpenter (74) vary as between soft and hard curd milk is not known but has been suggested as a possible difference (83).

The curd tension of milk may be elevated by removing fat in the form of cream or lowered by adding cream (22, 35, 37, 71). Natural high fat milk, being richer in casein as well, usually has a high curd tension compared with natural low fat milk. The curd tension of milk may be lowered by increasing the pH artificially (22, 83) which makes the reaction less suitable for enzyme coagulation.

The opinion of Weisberg *et al.* (83) as to the mechanism in milk which influences and determines the curd character is probably correct and worth reiterating. They hold, that the colloidally dispersed phase differentiates a soft curd from a hard curd; that concentration and manner of dispersion of the fat, casein, and colloidal phosphates control curd character; that hard curd milk containing more numerous casein particles (and, therefore, coagulation centers) will form a more closely woven net-work on coagulation, resulting in less occlusion of the serum and a denser mass; that fat may contribute to the curd character by interrupting the growth of micellar casein threads, thereby, making a shorter grained texture; and that the degree of dispersion of the fat is as important as its concentration in affecting curd character. This view is compatable with the actions involved in reducing curd tension by various processes and modifications, if the necessity for calcium ions, to render the para caseinate insoluble, is stressed and if the effect of previous coagulation or denaturation of casein and its influence on enzyme action is considered.

Natural Variations in Curd Tension.—The curd tension of cows' milk, while shifting somewhat due to stage of lactation, season and other natural causes, is more or less an individual characteristic of the animal and persists from one lactation to another, at least to the extent that composition does not vary (17, 22, 36). Some investigators have not obtained data which would substantiate this statement (5, 66). There seems little doubt, however, that cows carefully selected for the low tension character of their milk, could be assembled and maintained as a herd without excessive turnover of members from one lactation period to another.

The curd tension of milk is high in the colostral period, drops to a low point in the second or third month of lactation, then slowly increases with the duration of lactation, reaching a high level when the milk flow becomes

small, and finally drops to zero when the properties of the milk become abnormal at the extreme end of the period (5, 17, 22, 35, 37, 60, 66). Season and atmospheric conditions affect curd tension in a parallel fashion to composition as would be expected (22, 37, 60). The curd tension is highest in November, December and January and lowest in May, June and July in most sections. Sudden and drastic changes in weather conditions also seem to influence curd character (36). In general it may be said that any natural influence which affects milk composition will be reflected in the curd tension.

Mastitis:—Sub-clinical mastitis infections (mild garget) of the udder cause a drop in the curd tension of the milk from the infected udder or quarters (2, 20, 31, 59, 71, 84), the amount varying with the degree of infection (32, 34, 35). This is very evident when milk from clean udder quarters is compared with milk from diseased quarters of the same cow. The decrease in curd tension is frequently sufficient to drop average milk into a soft curd classification (2, 31). Hansen, *et al.* (31) state that an infection caused by staphylococci does not affect curd tension but Anderson *et al.* (2) found that staphylococci infections had even greater effects than streptococcic, and in two cases of "coli-like" infection the curd tension was lowered to the greatest degree.

The cause of the decreased curd tension of mastitis milk appears to be due, primarily, to a lowered casein concentration (2, 22, 69, 70), although the higher pH of such milk is also probably a contributing factor (22). Anderson *et al.* (2) have further shown that a lower calcium and phosphorus content and particularly a change in the ratio of casein to calcium to phosphorus in mastitis milk is a significant influence. It should be noted that Dahlberg *et al.* (20) found little change in the curd tension of milk, as a result of sub-clinical mastitis, by the Hill or Miller procedures but noted a decrease when milk was coagulated with pepsin alone. The discrepancy appears to be due to the fact that their samples came from animals very mildly infected as indicated by the normal casein content and the very slight change in other constituents. It is certainly possible to obtain milk from diseased udders which is normal macroscopically and yet will show the definite changes in composition and properties that have been noted by most investigators. In fact Rowland and Zein-El-Dine (69) have proposed a test for mastitis based on the ratio of casein nitrogen to total nitrogen.

In view of the relationship between udder infections and low curd tension values of milk, it is essential in the commercial production and sale of natural soft curd milk to take unusual precautions in selecting uninfected animals when assembling a herd and in keeping the herd free from mastitis during milk production (2, 22, 31).

MODIFIED AND PROCESSED SOFT CURD MILK

Physicians have practiced milk modification for many years in an effort to find suitable substitutes for mother's milk in the artificial feeding of infants. The literature dealing with these efforts and the results obtained is much too extensive to review here. Let it suffice to say that, as Brennemann early pointed out (6), practically all of the successful modifications are effective primarily through their ability to alter the curd character of the coagulum obtained in the stomach; in other words to cause small curd particle size (33). This view has been substantiated in later studies by Lynch (50) and Jeans and Stearns (43), even for acidulated milk.

The boiling of fresh milk for infant use is widely practiced at present and it is the opinion of the Council on Foods of the A. M. A. that "All cow's milk used for the preparation of infant feeding mixtures should be boiled" (18). In addition to boiling or sometimes as a substitute for boiling, such modifications as: dilution; acidification; alkalization; the addition of cereals, lime water and certain colloids; and such processes as homogenization, base-exchange treatment, enzyme alteration or some combination of these, have their advocates.

Only such modifications and processes as can readily be used by the milk dealer in preparing a suitable milk basis for infant formulas will be discussed in this review.

Dilution.—When water or milk serum is added to milk the curd tension is decreased (22, 26, 83) more or less in proportion to the degree of dilution (22). Brennemann (6) found that dilution resulted in smaller, more porous curds in the stomach but Wolman (87) states that while dilution reduces curd tension, it does not alter the curd particle size in the "artificial stomach."

Heat Treatment.—The effect on curd tension of heating milk depends entirely on the temperature used and the time of exposure. Pasteurization has a negligible effect (5, 11, 22, 76). Heating at 160° F. for 30 minutes causes a distinct lowering of the tension (11), about on a par with a flash treatment at 180° F. (11, 22), while a 30 minute treatment at 180° F. or boiling for 5 minutes decreases the tension markedly, usually sufficient to render average milk (50–60 grams) definitely soft curd (under 30 grams) (11, 22, 76). Autoclaved milk and evaporated milk frequently exhibit no curd tension (22, 37, 61).

The effect of previous heating of milk on its reaction to rennin and pepsin has never been satisfactorily explained due to the obvious complexity of the changes occurring. It seems likely that the calcium ion concentration is decreased, the electrostatic charge carried by the casein micelles increased, some albumin rendered insoluble and the protein itself denatured (67), while at the higher temperatures (autoclaving and sterilizing) an actual heat coagulation of extreme fineness may also be produced (46) which renders the casein more or less immune to enzyme coagulation.

Acidification.—As the pH of milk is reduced from the normal (6.4 to 6.7) a toughening of the enzyme curd is observed until the pH drops under approximately 5.9. From this point down to the isoelectric point (pH 4.7) the curd tension decreases (22). This decrease is undoubtedly due to the progressive agglomeration or coagulation of casein in the acid form which interferes with the formation of the para casein curd induced by enzyme action.

It should be noted that the above observations do not apply when the tension is measured by the Hill test (36) using calcium chloride in the coagulant. In the latter case a maximum curd tension is obtained at a considerably lower pH (5.2 to 5.6) (22, 83).

The usual method of acidifying milk for infant use is to add acid (hydrochloric, citric, lactic, acetic, lemon juice, sauerkraut juice, etc.) to such a degree that a fine acid coagulation occurs in cold agitated milk. Little or no enzyme curd will be obtained with such pre-coagulated milk. The use of acid milk has been advocated by many pediatricians, chiefly as a result of the publications of Marriott *et al.* (53, 54, 55, 56). Gonce and Templeton (44) suggest citric acid as being superior for acidifying infant milk.

Homogenization.—When whole milk is homogenized the enzyme curd is rendered considerably softer (5, 11, 22, 71, 75, 76, 79, 82, 85). Skim-milk is not so affected (12, 22, 71, 78) which lends support to Weisberg's view concerning the relation of the degree of fat dispersion to curd structure (83).

The effects of homogenization vary with the curd tension of the milk processed, the fat content, the pressure used, and the auxiliary heat treatment. Hard curd milk is softened to a greater degree than soft curd milk although usually not sufficiently to place it in a soft curd classification (5, 11, 22, 75). High fat milk requires higher pressure of homogenization to bring about maximum decreases in curd tension (22, 44). Pressures over 2500–3000 pounds accomplish little (11, 22, 76) with average milk but under this point the tension falls as the pressure is increased, although not proportionately (5, 11, 22, 75, 76). Two stage processing and dual homogenization appear to have little effect not noted with comparable single valve treatment (17, 75, 76).

The temperature treatment of the milk before and during homogenization exercises considerable influence on the results. A greater effect, naturally, is noted when milk is processed at high temperatures due to the additive action of the heat and the homogenization (11, 22, 44, 76) but at very high temperatures (180° F. to boiling) homogenization produces little or no additional lowering of the tension under what is accomplished by the heat alone (44).

Differences between the preheating or pasteurizing temperatures and homogenizing temperatures exercise an influence divorced from the heat

effect itself. Curd tension is reduced to a greater degree when the milk is cooled down to 100°–120° F. before processing rather than to homogenize at the preheating or pasteurizing temperature (11, 22, 85). The greatest reduction appears to be obtained when the temperature range through which the milk is cooled is greatest (22).

All of the above effects have been noted with high pressure, piston machines. At present there are on the market and in use low pressure, rotary homogenizers, which pressure for pressure, seem to have slightly more effect in reducing the curd tension of milk than the piston machines (23). Since their pressures are limited to less than 1000 pounds, they are not capable of producing the amount of change possible with piston machines at 3000 pounds pressure (23, 77).

The curd tension of milk may also be lowered and the product homogenized by conducting it, in a thin layer, over a diaphragm, oscillating at high frequency (12). This process developed by the Submarine Signal Company apparently produces the same general results as are obtained with low pressure homogenization but without any appreciable pressure (12, 13, 23, 28, 87). The method is being used commercially in a few places, the product being known as "sonized" homogenized milk. The amount of experimental work carried on with this process has been rather limited.

Any explanation of the effect of homogenization on the curd tension of milk hinges, without question, on the increased dispersion of the fat which introduces more points of weakness in the coagulum, in line with Weisberg's theory (83). The increase in adsorbed protein may also be a factor since it is quite possible that this membrane protein may not participate in the coagulation in the same manner as it would in the motile state. It has also been noted that the curd from homogenized milk is more highly hydrated than from unhomogenized. This may be a factor in softening the coagulum (29). Again, homogenization may displace some of the normal phospholipide-protein complex from the fat globule surface, releasing it into the plasma in a manner similar to churning. This would affect the tension of the curd (63). Finally, recent work (52) has shown that homogenization raises the freezing point of milk, indicating an adsorption of solutes some of which may be calcium. This would effect the rigidity of the peptic or rennin coagulum under the conditions of the determination.

Base Exchange Treatment.—A method was devised a few years ago (48, 49) for retarding enzyme coagulation of milk by the removal of a considerable portion of the soluble calcium. This is a base-exchange process wherein acidified milk (citric acid) is percolated through a zeolite bed, giving up calcium and phosphorus (about 20 per cent) in exchange for sodium and potassium. By properly regulating the conditions, milk with normal pH and normal ratios of calcium to phosphorus and sodium to

potassium can be obtained. Such milk is low in ionized calcium and will usually exhibit a curd tension between zero and 10 grams by the Miller technique. Where the Hill test is used no reduction of curd tension will be evident because of the calcium of the reagent. This product is being marketed in several cities under the name "Sof-Kurd" milk.

One of the frequently voiced objections to "Sof-Kurd" milk is the removal of nutrient minerals, the value of which have been stressed for years and upon which much of the nutritional excellence of milk has been based. However, Hess, Poncher and Woodward (34) in a study using one infant show that the retention of calcium was higher on base-exchange milk than on normal milk. This evidence is hardly sufficient to be conclusive and the subject needs more study.

Another objection to base-exchange milk is the fact that the product is sensitive to temperature changes. Boiling (48) or even heating to temperatures over 100° F., if held for an appreciable time, (29) causes a readjustment of the ionic equilibrium such that curd tension values are considerably increased. The action is reversible and returns to the original value on cooling and holding at low temperature (29, 48). The product is therefore somewhat temperamental and the usual procedures for preparing infant feedings may possibly give rise to variable fluctuations in the curd character of this milk in the stomach.

Enzyme Treatment.—Conquest, Turner and Reynolds (16) have proposed a method of reducing the curd tension of milk which employs a period of incubation with an extract of hog pancreas followed by prompt pasteurization. This method is too new to evaluate as yet but seems to offer possibilities. The use of trypsin in similar fashion has been studied by Flora (29) who was able to obtain decreases in curd tension approximately as great as are possible with homogenization, without appreciably affecting the flavor of the milk although, in some cases, the creaming ability was altered.

Treatment of this type is in the nature of a pre-coagulation possibly combined with some denaturation and decomposition of the protein and the effect on a subsequent gastric coagulation is probably not dissimilar from that obtained with acidification, renneting, or high heat treatment.

Agitation.—Lundstedt (47) suggested a method of lowering the curd tension of milk by agitation and churning at low temperature. He claimed that the lecithin of the fat globule membrane was removed and adsorbed by the casein thereby modifying the coagulation properties. Palmer and Tarassuk (63) were unable to duplicate Lundstedt's results on agitation but they did show that when the fat globule membrane (phospholipide-protein complex) is removed from the globule in the process of churning, the curd tension of the resultant buttermilk is considerably lowered.

THE DIGESTIBILITY OF SOFT CURD MILK

The value of soft curd milk, or any modified milk, for infant or invalid use rests on its digestibility characteristics. The curd tension value has been offered as an index of digestibility but has not been definitely proven a satisfactory one. Neither has it been proven definitely unsatisfactory. The size of curd particles formed when milk is coagulated by gastric enzymes is believed to be related to ease of digestion or rate of stomach clearance. Until recently no method of measuring curd particle size was used other than regurgitation of ingested milk and examination of the curds obtained. This index, therefore, also awaits definite substantiation as a measure of milk digestibility. In vitro methods of determining the digestion characteristics of milk have been used to a considerable extent. They are useful in obtaining positive results and in studying phases of the problem difficult or impossible to follow in vivo but procedures have varied so greatly that it is frequently difficult to evaluate the results obtained. In vitro methods which simulate conditions and changes occurring during infant digestion should be productive of useful information but they are always open to the criticism that the conditions are artificial and therefore inconclusive. Methods of rating digestibility utilizing the digestive systems of animals may or may not be more indicative than in vitro methods, depending on the accuracy with which results can be noted or measured and on the similarity existing between the digestive system of the animal and the human infant. In the last analysis any index of digestion must be substantiated clinically with infants; otherwise its meaning and its value are uncertain.

Up to the present only a few studies have produced results which make it possible to accurately evaluate any of the indices discussed and still fewer are available to indicate the usefulness of the more recently suggested methods of processing milk to render it a more suitable base for infant formulas.

Observations with Humans.—It is common knowledge that evaporated milk, boiled milk and acidified milk have proven satisfactory as substitutes for breast milk in infant feeding (8, 18, 57, 65). Although all of these milks have very low curd tension values, their success has generally been ascribed to the fineness of the coagulum found in the stomach following their ingestion (8, 43, 50, 64). There seems to be little doubt but that boiled, evaporated or acidified milks are evacuated from the human stomach more rapidly than similar untreated milk (6, 22, 29, 51, 72). This has also been found true with animals as will be indicated later. Ogilvie and Peden, (62) however, found little difference between boiled and raw milk in infants, where stomach tubes were used to sample the gastric contents and Davidson, *et al.* (21) was not able to find appreciable differences between ordinary milk and several types of modified milk (including evapo-

rated) when fed to adults with barium and the rate of stomach emptying noted by means of a fluoroscope. It might be pointed out, however, that Brennemann (6) found in numerous cases that a stomach tube was inadequate for sampling gastric contents and it has never been shown that the admixture of barium sulfate does not greatly alter the characteristics of the milk coagulum in the stomach.

In case studies and clinical observations reported by Hill and others, (4, 17, 36, 37, 39) natural soft curd milk is described as being very satisfactory for infant use, overcoming digestion disturbances such as vomiting, regurgitation, colic and undigested protein in the stools. Elias (25) and Morris and Richardson (60), on the other hand, failed to note any decided advantages for natural soft curd milk over the usual satisfactory formulas. The results reported by these workers are not too indicative inasmuch as Elias' babies ranged up to 2 years in age and the boiled certified milk utilized by Morris and Richardson averaged lower in curd tension than the soft curd milk which was fed raw in most cases. Data presented by the latter workers indicate that their infants on soft curd milk did as well as those on evaporated milk.

Several investigators have noted that natural milk of low tension gives rise to smaller and softer curds in the stomachs of infants and adults (3, 17, 22, 25) as judged by regurgitation tests or the use of stomach pumps. Anthony (3) found the same to be true of homogenized milk but not of base-exchange treated milk.

Homogenized milk and most of the other types of processed milk have been insufficiently studied with humans to make conclusions possible. Wolman (87) states, apparently as a result of in vitro studies, that adequately homogenized milk is an excellent foundation for infant formulas and Wilcox (86) reports, as a result of Roentgenological studies with adults, that homogenized milk leaves the stomach in advance of soft curd milk and average milk.

The common conception that the fat of homogenized milk is more assimilable by infants because of its greater dispersion seems unfounded in view of the studies of Holt and co-workers (41).

Rogers, *et al.* (68) found base-exchange treated milk to be a good complemental food for new born infants, better gains and fewer losses resulting than where untreated milk was used and, as previously noted, one very limited study (34) indicated that the lack of calcium and phosphorus in base-exchange treated milk does not impair its nutritive value since the remaining minerals are assimilated to a greater degree.

Observations with Animals.—Digestion comparisons have been made with soft curd milk, boiled milk, acidified milk, evaporated milk and a few of the other types of modified milk using such animals as dogs, calves and rats. Some of the results obtained appear quite indicative but there

have been far too few such studies to warrant placing much weight on them, particularly since the digestive apparatus of calves is quite dissimilar from humans and the stomachs of adult dogs appear not to coagulate milk normally (33).

Working with dogs, Espe and Dye (26) concluded that soft curd milk leaves the stomach quicker than normal or hard curd milk. The same conclusion has been reached in other studies using calves (22, 27, 61) and rats (22) and for boiled milk and whole milk as compared with unboiled milk and skimmilk respectively (27, 61). It has also been shown that soft curd milk, buttermilk and evaporated milk travel farther and disappear more rapidly in the intestines of rats than does hard curd milk (22). Hess and co-workers (33) found that modified milks (boiled and acidified) form loose, small curds in the stomachs of puppies, whereas raw and pasteurized milks form large tough coagula. Milk treated with enzymes of the hog pancreas to reduce the curd tension and fed to calves was observed by Conquest, *et al.* (16) to have an increased rate of stomach clearance compared with normal untreated milk.

In some recent studies, Flora (29) observed that natural untreated milk is digested by rats at a rate roughly proportional to the curd tension but that homogenized milk (by whatever method processed) and to a much lesser degree, base-exchange treated milk digest at a slower rate than the respective curd tensions would seem to indicate.

In Vitro Studies.—It is difficult to decide how much confidence to place in the methods which have been devised for measuring the digestibility of milk by laboratory means inasmuch as clinical substantiation of the results is usually lacking and inasmuch as little information has been obtained regarding the actual conditions under which milk coagulates in the infant stomach. Marriott and Davidson (54) present the following data regarding the pH of the infant stomach at the height of digestion (2 hours after feeding).

	Breast Fed	*Cows Milk*	*Acid Milk*
Normal	3.75	5.10	3.71
Abnormal	4.74	5.35	4.10

These values are much higher than obtain in adult digestion (32) and since it has been shown that cows milk is coagulated in adults at a pH of 5.9 or higher 10 minutes after ingesting one pint of milk on an empty stomach, (22) it seems reasonable to believe that coagulation in the infant stomach takes place at a pH at least this high and perhaps higher.

A "rennin type" curd is obtained when milk is coagulated with peptic enzymes at a pH of 6.0 or above. Between pH 5.0 and pH 6.0 the coagulum appears to be a mixture of the acid and rennin types, while at a pH of less than 5.0 the curd is predominately acid in type. The character of the coagulum (curd tension and curd particle size) will vary with the

reaction at which it forms (22, 42) as will also its digestion properties (42). It therefore appears evident that, in methods for following rates of digestion in vitro, the conditions under which the milk is coagulated are of prime importance and should simulate the conditions in the infant stomach as closely as possible. Furthermore it is the writers belief that the conditions should conform to those found in the new born rather than to those existing in babies six months or over in age. It seems axiomatic that any type of milk which proves satisfactory in new born babies will cause no difficulties with older ones. It is in the very young that most difficulties with cows' milk are experienced.

Hess *et al.* (33), using an in vitro method set up to simulate stomach conditions concluded that, while curd particle size is a most important factor in digestion, other influences are also of moment. They found that boiling milk lowers the soluble nitrogen content as does also acidification, but both of these factors favor peptic digestion. This in itself is evidence that the physical character of the curd is of first importance and overshadows other lesser effects. Schultz and Fetter (73) found that milk containing rennin (Junket) is acted upon more rapidly by pepsin. Wallen-Lawrence and Koch (80) observed that heated milks (boiled and evaporated) are attacked more rapidly by trypsin than unheated milk and explained this as being the result of the destruction (by heat) of a labile trypsin inhibitor found in the whey of raw milk. Doan and Welch (22) showed that soft curd milk digests faster at any pH than does hard curd milk and that peptic digestion appears to be a peripheral process as far as nitrogen break down is concerned. Lear and Skaggs (45) found that natural soft curd milk has superior digestion qualities to normal milk and that boiled milk and homogenized milk have inferior qualities. Their results with boiled milk were due to the fact that soluble nitrogen was taken as an index of stomach digestibility and, as has been indicated (33), boiling itself lowers the soluble nitrogen. Chambers and Wolman (14) and Wolman (87) have reported enhanced digestibility for homogenized milk, heated milk, natural soft curd milk and various types of modified milk. Their method made use of thin walled rubber bags ("artificial stomachs"), in which a type of agitation more nearly approaching peristalsis was obtained. Their measure of digestibility was the curd particle size or the curd surface area which resulted when the various milk samples were treated under uniform conditions to simulate coagulation and the first stages of digestion in the stomach. Their results indicate that curd tension correlates quite satisfactorily with curd particle size except with a few unusual types of modified milk. A pH of 4.5 which was used in these studies might be criticized as being too low, particularly when used as the coagulation reaction.

Studies recently reported by Hull (42) show that homogenized milk does not digest any more easily than unhomogenized milk but that evaporated milk, base-exchange treated milk and boiled milk do have enhanced digestion qualities. His results indicate that the pH at which the curd is formed has a very definite influence on the curd particle size and hence on digestibility. At the lower pH levels (5.2–5.7) the curd is less adhesive and in smaller aggregates and the breakdown is more rapid than at the higher levels (5.9–6.4). Flora's (29) work substantiates that of Hull, in many respects, although in the in vitro method used, tryptic digestion followed peptic and the results obtained were checked utilizing rats. He concludes that homogenized milk digests no better than unhomogenized, that curd tension is not an accurate index of digestibility with this type of milk or with base-exchange treated milk, that enzyme treated milk shows good peptic digestion characteristics and that any milk to be highly satisfactory as a base for infant formulas should have a curd tension of zero. In addition Flora noted increased tryptic activity with the heated milks (boiled and evaporated) in line with the findings of Wallen-Lawrence and Koch (80).

The available information on the digestibility of natural and processed or modified soft curd milk is inadequate to be conclusive. In some respects it is conflicting. There seems little doubt but that natural soft curd milk is more suitable for infant feeding than normal or hard curd milk but whether it is sufficiently more digestible to warrant its production is questionable since it does not seem to offer any definite advantages over evaporated milk, acidified milk and perhaps most boiled milk.

Homogenized milk (including sonized) has not reacted very favorably in some in vitro studies so that until further studies are made and particularly until careful clinical comparisons are available little can be offered in support of it. Base-exchange treated milk also needs further substantiation as an entirely satisfactory infant food. Present information would indicate that it is probably in a class with natural soft curd milk in that it seems to be more digestible than normal milk but not so digestible as evaporated and acidified milk.

Enzyme treated milk has been studied even less than the others. Results obtained by one or two workers indicate that it may have possibilities in infant feeding if and when a satisfactory method of preparing it is developed.

Much doubt has been cast on the curd tension value of milk as a satisfactory index of digestibility. It is the writer's opinion that the *size* of curd particles obtained in peptic coagulation under conditions of agitation and acidity closely approximating those existing in the stomachs of young infants would be a more suitable index than the *toughness* of the curd formed without any agitation. However, the pH at which coagulation is

to be accomplished would be a factor needing substantiation and one to be accurately controlled. Observations on this point with infants are lacking.

In conclusion it should be emphasized that, at present, none of the suggested methods of preparing a fresh fluid milk for pediatric purposes appears to be sufficiently satisfactory. At least evidence in their favor is too meagre or too fallible to constitute definite proof of their sufficiency. Instead of being content to promote the use of a half-satisfactory product or a product only half substantiated, the milk industry should redouble its efforts to develop a type of fresh cow's milk which will meet every requirement of the human infant or to thoroughly prove the excellence of existing types in a manner acceptable to pediatricians.

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American Dairy Science Association Announcements

RESULTS OF ELECTION

The results of the election of officers on October 1 were as follows:

Vice President: E. S. Guthrie, Cornell University, Ithaca, N. Y.

Directors to serve for three years each:

J. W. Linn, College of Agriculture, Manhattan, Kansas
M. E. Parker, Beatrice Creamery Co.,
1526 South State Street, Chicago Illinois

ANNUAL MEETING AT IDAHO AND WASHINGTON, WEEK OF JUNE 26, 1939

Our next annual meeting is to be held the week of June 26, in Moscow, Idaho, and Pullman, Washington. Will you please inform the secretary if you are interested to go by train and if so, would you use Pullman or Tourist Pullman beyond Chicago? A card stating your preference will in no way obligate you for the trip. This is merely to find out if it is worth turning over to the railroads who will close any contract if made. If enough interest is shown, we may arrange to have a special car or train so that you may go from the East to the meeting together.

	New York	Washington	Columbus	Chicago
Rail Fares Using Pullman	$128.40	$120.50	$94.20	$76.05
" " " Tourist Pullman beyond Chicago	118.45	110.55	74.25	66.10
Pullman Fares	20.00	19.50	16.50	14.00
" " Using Tourist Pullman beyond Chicago	13.50	13.00	10.00	7.50

A REVIEW ARTICLE

Beginning with the October issue, the editor has invited authorities to write on a specific subject. From six to twelve of these review articles will appear each year. In the October issue, Mr. C. J. Babcock has covered the subject of feed flavors in milk and milk products. We believe these review articles will be a great asset to the JOURNAL.

ASSOCIATION NEWS

Upon receipt of your JOURNAL will you please look for Association announcements? They will be found immediately preceding the abstracts.

Your officers will appreciate suggestions and criticisms in operating the Association, publishing the JOURNAL, etc.

We should appreciate your comment regarding the exhibit displayed at the National Dairy Show and the Dairy Industries Exposition.

BORDEN AWARD

Have you anyone in mind to be nominated for the Borden Award? These committees will no doubt be asking for nominations in the immediate future.

VOLUME XXI NOVEMBER, 1938 NUMBER 11

JOURNAL OF DAIRY SCIENCE

Published by the
AMERICAN DAIRY SCIENCE ASSOCIATION
R. B. STOLTZ
Ohio State University, Columbus, Ohio, Sec.-Treas.

ABSTRACTS OF LITERATURE

T. S. SUTTON, Editor
Columbus, Ohio

MILK AND MILK PRODUCTS

Published in cooperation with
INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS
R. C. HIBBEN, 1105 Barr Bldg., Washington, D. C., Exec. Sec.

INTERNATIONAL ASSOCIATION OF MILK DEALERS
R. E. LITTLE, 309 W. Jackson Blvd., Chicago, Illinois, Exec. Sec.

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American Journal of Public Health
Archives of Pediatrics

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Certified Milk
Cornell Veterinarian

Deutsche Molkerei Zeitung

Endocrinology

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Journal of Agricultural Research
Journal of Agricultural Science
Journal of American Chemical Society
Journal of American Veterinary Medicine Association
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Zeitschrift für Infektionskrankheiten Parasitäre Krankheiten und Hygiene der Haustiere
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SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers

International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England

New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

519. A Study of Comparative Methods and Media Used in Microscopical Examination of Creamery Butter. I. Yeast and Mold Counts. G. W. SHADWICK, Beatrice Creamery Co., Chicago, Ill. Food Research *3*, 3, 287, May–June, 1938.

This paper presents the results of a comparative study of yeast and mold counts for salted and unsalted butters using as culture media freshly prepared potato-dextrose agar and the dehydrated potato-dextrose, malt, peptonized-milk, whey, and wort agars prepared by the Difco Laboratories.

F.J.D.

520. Heat Resistance Studied on Spores of Putrefactive Anaerobes in Relation to Determinations of Safe Processes for Canned Foods. C. T. TOWNSEND AND J. R. ESTY, Univ. of Calif., Berkeley, Calif., AND F. C. BASELT, American Can Co., New York City. Food Research, *3*, 3, 323, May–June, 1938.

Thermal death curves for *Cl. botulinum* in neutral phosphate media and in vegetables and milk are different. Data are presented from which safe temperatures and time intervals for sterilization may be chosen.

F.J.D.

521. The Respiration of the Rod-Shaped Lactic Acid Bacteria. P. ARNE HANSEN, Royal Tech. College, Copenhagen. Zentr. Bakt. II, *98*, 289–297, 1938.

The rate of respiration of 12 strains of lactic acid bacteria of known origin has been studied. Species of the genera Thermobacterium and Streptobacterium show very low rate of respiration and are not inhibited by hydrocyanic acid, while the genus Microbacterium gives high values and the rate of respiration is considerably decreased by HCN. It is recommended to consult quantitative respiration experiments in taxonomic work.

J.C.M.

522. Counting Bacteria. S. ORLA-JENSEN AND G. FAULENBORG, Royal Tech. College, Copenhagen. Zentr. Bakt. II, *97*, 387–389, 1938.

Comparative counts of bacteria were carried out on milk samples each of which were divided in four parts and treated as follows: one was left raw; the second pasteurized at 63° C for 30 min.; the third heated at 80° C for 2 min.; the fourth sterilized. Both plate counts and direct microscopic

counts were used. In the latter case the individual cells as well as groups of cells were separately recorded. Observations were carried out over a period of 10 days, samples being removed at once and at intervals, temperature of incubation was 5° C., chloroform was added. The dead bacteria present gradually disappeared, after two days in the sterilized milk; after 8 days in the milk heated to 80° C. The simultaneous use of plate and direct counts is advocated. J.C.M.

523. **The Hemolytic Streptococci of Milk.** C. F. NIVEN, Dept. of Dairy Industry, Cornell Univ., Ithaca, N. Y. Milk Dealer, *27*, 11, 64–67, August, 1938.

A total of 313 samples of commercial milk, 68 raw and 245 pasteurized, were examined for hemolytic streptococci. Narrow-zone hemolytic types in blood agar, the most typical form of *Streptococcus mastitidis,* were not considered. Only 8.5 per cent of the pasteurized samples contained hemolytic streptococci, as here defined, whereas broad-zone hemolytic types were obtained from 18 per cent of the raw samples.

The cultures isolated were studied serologically and physiologically, and, on the basis of these results, six groups or species were recognized: *Streptococcus mastitidis* (Lancefield group B), the "animal pyogenes" (Lancefield group C), *Streptococcus durans* (Lancefield group D), *Streptococcus zymogenes* (Lancefield group D), and two other types which differ serologically and physiologically from any adequately described species of streptococcus.

The prevailing types of hemolytic streptococci in raw milk are *Streptococcus mastitidis* and the "animal pyogenes"; the most common forms in pasteurized milk are *Streptococcus durans* and *Streptococcus zymogenes.*

C.J.B.

524. **The Phenomenon of the Extensibility of Ferments.** W. M. BOGDANOW, Institute for Scientific Research in the Dairy Industry, Leningrad, U.S.S.R. Le Lait *18,* 176, 576–582 (June, 1938).

An organism is described which causes the development of a stringy condition in milk. A stable symbiosis possesses high proteolytic activity. During prolonged incubation of the ferment, the acidity gradually decreases and a strong peptonization of the albumin takes place. The combination of organisms described is acceptable for cheese making. A.H.J.

BREEDING

525. **A Factor in Breeding Efficiency of Dairy Cattle.** HOWARD CLAPP. Proc. Amer. Soc. Animal Prod. *30,* 259–265, 1937.

At this large breeding establishment (Pabst Farm) it was found that the mean interval between calving and the first oestrum following was 46.4

days for cows milked twice daily, 69.4 days for cows milked four times daily (test cows), and 71.8 days for cows nursing calves. Among the group on test there was no difference in interval due to the month of freshening, but in the group not on test there was a slight significant difference, the shortest intervals occurring in December to February freshening cows. G.C.W.

Other abstracts of interest are 542, 554, and 560.

BUTTER

526. The Spreading Capacity of Butter. G. W. Scott Blair, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 208–214, 1938.

An instrument designed to study the rheological properties of butter is described. The time required for a given weight to compress a cylinder of butter through a given distance is used to calculate the viscosity of the butter. S.T.C.

527. Studies of the Keeping Quality of Butter in Cold Storage. O. R. Overman, O. F. Garrett, and H. A. Ruehe. Ill. Agric. Exper. Sta. Bull. 446, Sept., 1938.

"The purpose of this investigation was to study butters of differing quality and from differently treated creams during extended periods of storage at customary storage temperatures in order to determine the influence of various factors upon the keeping quality of the butter, and especially to determine whether correlation exists between the keeping quality of butter and the results obtained by a laboratory examination of the fat."

A review of the literature and bibliography of sixty-six references is given.

During the investigation reported the behavior in cold storage of thirty-six different butters ranging in quality from poor to excellent was studied. The butters were stored in 3 pound packages, 10 to 12 packages of each butter being available. The butters were subjected to laboratory examination at definite intervals.

The examination included scoring of the butter and the determinations on the filtered fat of index of refraction, iodine absorption number, saponification number, soluble acids, insoluble acids, free-fatty acids, acetyl value, Reichert-Meissl, Polenske, and Jensen-Kirschner numbers, the pH of the serum and the computation of the mean molecular weights of the fats. The rates of oxygen absorption of the fats were determined also.

The following observations and conclusions were made as a result of this study:

1. The judge's score of a butter, although a statement of quality at the time of scoring does not give any indication of its keeping quality.

2. The particular chemical and physical constants determined do not show correlation with keeping quality.

3. The induction periods and the rates of oxidation vary so irregularly that there is no evidence of any relation of these to keeping quality.

4. Butter made from sweet cream scored higher and held its score better in storage than butter made from the same cream after ripening with starter and partial neutralization, and the latter was correspondingly better than butter made from the same cream after spontaneous souring and neutralization to the same percentage of acidity.

5. Different neutralizers used to reduce the acidity of separate lots of the same cream to approximately the same percentage of acidity did not affect the initial score or the keeping in storage.

6. Butter from cream ripened with starter to .44 per cent acidity and churned without neutralization scored higher and held its score better in storage than did butter from the same cream after it was ripened with starter to .61 per cent acidity and churned without neutralization. The latter was correspondingly better than butter churned from the same cream without neutralization after ripening with starter to .82 per cent acidity.

7. Overneutralization of cream produced a butter with low initial score and poor keeping quality.

8. Butter churned from sweet cream and salted scored slightly higher but lost score more rapidly than unsalted butter from the same cream.

9. The butters which were given the highest initial scores and held their scores best of all those studied in these investigations were churned from fresh sweet cream separated from fresh sweet whole milk. These butters were not salted and were of salable quality after about two years in storage.

O.R.O.

528. Treatment and Transformation of Milk, Improvement of Quality. The Aroma of Butter. W. Mohr, Kiel, Germany. Le Lait *18*, 177, 743–758 (July, August, 1938).

The principle aromatic substance in butter is diacetyl. The formation of diacetyl is due to the action of bacteria on citric acid. Formation of diacetyl and acetyl methyl carbinol are related but the mechanism of their formation is not definitely known. Among the problems in this connection are whether both substances are formed simultaneously or whether diacetyl is formed from the oxidation of acetyl methyl carbinol and if such is the case, by what mechanism, or if diacetyl is produced simply from acetaldehyde in the course of oxidation with subsequent condensation. Increasing acidity and aeration favor the production of diacetyl. High temperatures at the time of proper acidity, notably the temperature optimum for the growth of bacteria are not favorable for the production of

diacetyl. Diacetyl is formed more rapidly between 12° C. (53.6° F.) and 16° C. (60.8° F.) or between 17° C. (62.6° F.) and 21° C. (67.8° F.) with cooling of the culture to 10° C. (50° F.) when the acidity has increased to 23° S.H. The conditions that apply to the formation of diacetyl and acetyl methyl carbinol in cultures apply equally in the cream used for butter making. During churning the content of diacetyl and acetyl methyl carbinol increases and is significantly higher in the buttermilk than in the cream. The butter contains about 1/4 the diacetyl and 1/15 to 1/16 the acetyl methyl carbinol found in the ripened cream. The diacetyl and acetyl methyl carbinol are found distributed throughout the butter in the aqueous phase of the serum and not at all in the fatty phase. The washing of the butter eliminates a considerable part of the diacetyl and acetyl methyl carbinol. At ordinary temperature and for short storage periods, *i.e.*, at 10° C. (50° F.) and up to 4 days, there results an increase in diacetyl. Within 10 to 12 days, however, the diacetyl decreases. On storage at low temperature 0° to 10° C. (32° F. to 14° F.) the content of diacetyl does not undergo change.

Butter made from sweet cream contains only very small amounts of diacetyl, nor is diacetyl formed during prolonged storage for as long as 6 months. Methods of determining diacetyl and acetyl methyl carbinol are discussed. It is emphasized that differences in methods and technique account for the variation in results obtained by different investigators and that this makes it difficult to interpret results from different laboratories. A rapid practical method that will give reliable results and that will be applicable both to research and control laboratories is needed.

A.H.J.

529. Keeping Quality of Butter. Johannes Jensen and W. Ritter, Aabenraa, Denmark, and Berne-Liebefeld, Switzerland. Le Lait *18*, 177, 758–773 (July, August, 1938).

Fishy flavor in butter is due to the formation of tri methylamine originating from lecithin as a result of hydrolysis and oxidation. The oxidation is markedly accelerated by the presence of small amounts of metals, particularly iron and copper. Copper is about 13 times as effective as iron in catalysing the oxidation. Pasteurization at 90° C. (194° F.) of the cream from which the butter is made operates to prevent the development of the fish flavor. This is due in part to destruction of bacteria and probably partly to antioxidants formed at the high pasteurization temperature. Some types of bacteria in butter reduce the rate of fishy flavor development in butter by consuming the oxygen contained in the butter. The acidity of the cream from which the butter was churned is important in controlling the keeping quality and should not vary from the desired acidity of 23 to 25 S.H. Stored butter derived from cream of acidity 20 S.H. has a tendency to mold, while butter derived from cream of acidity more than 29

S.H. becomes rancid prematurely. Butter oil prepared by the boiling method is a satisfactory means of storing butterfat for considerable periods with less danger of off flavor developing than if butter itself is stored. The butter fat prepared by this method, however, possesses flavors imparted to it by the cooking process while the natural aroma of the original butter may have been driven off. Methods of packaging butter to prevent the development of off flavors is discussed. Light is the chief factor involved in off flavor development in packaged butter. Protection from light by black paper or metal foil or papers containing materials that absorb ultra violet are described. Variations in the chemical characteristics of butter take place from season to season as a result of change in the feed of the cows. Thus the average saponification number was found to be 232 from December to February and 222 in summer. The Reichert-Meissl-Vollny number had a value of 33 in winter and 29 in summer. The Polenski number had an average value of 5 in winter and 3 in summer. The xylol index averaged 23 from February to April and about 20 in July and August. The index of refraction was 1.4537 in winter and increased to 1.4555 in summer. The iodine number increased from 35 in January to 41 in summer. The effects of individual feeds and feeding régimes on the chemical constants of the butterfats are discussed and data presented. A relation between the fat content of the milk and the iodine number of the fat is observed. If the fat content of the milk increases, the iodine number of the fat decreases. Butter of an iodine number of 28.5 to 34.5 is, from the physical point of view, considered to be satisfactorily conditioned. Butter with an iodine number above 34.5 is considered too soft and below 28.5 it is too hard and brittle. A.H.J.

Other abstracts of interest are 519 and 559.

CHEESE

530. The Calcium and Phosphorus Contents of Some Types of British Cheese at Various Stages during Manufacture and Ripening. E. C. V. Mattick, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 233–241, 1938.

The calcium and phosphorus contents at various stages in the manufacture and during ripening of Cheddar, Cheshire, Leicester, Lancashire and Stilton cheese were determined. There was little difference in the values of the hard pressed varieties, however, Stilton cheese contained much less calcium and considerably less phosphorus than the hard pressed cheese. From about 50 to 60 per cent of the original calcium of the milk was left in the hard pressed cheese after 8 months, and only about 7 per cent in Stilton. S.T.C.

531. The Rôle of Bacteria in Milk Destined for the Fabrication of Gruyère or Emmental Cheese. W. DORNER, Agronomic Engineer for the Federal Institution of the Dairy Industry, Liebefeld, Switzerland. Le Lait *18*, 175, 449–455 (May, 1938).

The numbers of bacteria play a very important rôle in the preparation and ripening of cheese. Harmful bacteria are more harmful when they are more numerous, and useful bacteria may be harmful when they are too numerous. *Bacterium amylobacter* causes a swelling up of the cheese and *Bacterium proteolyticum* causes a secondary offensive fermentation. With the exception of *Bacterium coli* and *aerogenes* when they come from mastitis, the pathogenic bacteria are not susceptible directly of causing difficulty with the preparation of Gruyère or Emmental cheese. A.H.J.

532. Volatile Acids of Cheese. II. Methods of Extraction. E. R. HISCOX, J. HARRISON, AND J. Z. WOLF, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 227–232, 1938.

A method for estimating the volatile acids in cheese based on the steam distillation of a water extract of the cheese is described. Considerably higher results were secured with this method than by direct steam distillation. S.T.C.

533. Volatile Acids of Cheese. I. Retentive Power of Cheese and Its Constituents. E. R. HISCOX AND J. HARRISON, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 215–226, 1938.

To determine the exhaustiveness with which the various acids could be recovered by steam distillation acetic, propionic, butyric, caproic, caprylic and lauric acid solutions with added cheese fat, butter fat, cheese protein and casein were steam distilled using a standard procedure. The fat portion of the cheese was found to have a retarding effect on the distillation of the higher volatile fatty acids. The cheese protein appeared to be capable of a permanent retention of a part of some of the acids present. The results indicate that a more accurate picture is gained of the distribution of the acids present by collecting only "twice the original volume" rather than by distilling to "5 times the original volume." S.T.C.

534. Chemical Changes During the Melting of Natural Cheese. M. KVETON, Polytechnic High School, Prague, Czechoslovakia. Le Lait *18*, 176, 561–575 (June, 1938).

There is little change in the properties of the butterfat in cheese as a result of melting in the presence of disodium phosphate or sodium citrate.

No significant change results in the Reichert-Meissl, Wauters Polenske or iodine values. The acidity of the fat is reduced slightly (on the average 2.5%) due to the melting in the presence of the alkaline salts. The soluble nitrogen is much higher in the melted cheese than in the natural cheese, increasing from about 11% of the dry matter in the natural cheese to about 40% in the melted cheese. The increase in soluble nitrogen is greater when disodium phosphate is used than when sodium citrate is used. The ash content of the melted cheese is higher than for natural cheese due to the added mineral salts. It is suggested that the higher ash content may be used to distinguish between natural and so-called "processed" cheese. The melting of the cheese increases the titrable acidity due to the effects of the alkaline salts on the proteins of the cheese. A.H.J.

535. Milk Organisms in Cheese Making. CONSTANTINO GORINI, Milan, Italy. Le Lait *18*, 177, 711–712 (July, August, 1938).

It is emphasized that milk organisms play a favorable role in the ripening of Gruyere and Emmental cheese because of their solubilizing action on casein. This group of organisms accordingly acts as activators for the lactic ferments. Gorini states that Dorner was incorrect in his conclusion that Gruyere and Emmental were not favorably affected by this group of organisms just as was the case for the other types of cheese. Even though organisms themselves might be destroyed in the process of cheese making, enzymes elaborated by them exert a favorable role in the maturing of cheese. A.H.J.

CHEMISTRY

536. The Determination of the pH of Lactic Acid Casein. JEAN PIEN AND M. WEISSMANN, Laboratories of the Farmers Union, Paris, France. Le Lait *18*, 175, 455–462 (May, 1938).

The pH of the casein solution may be used to indicate if the protein has been precipitated above its iso-electric point, if the washing has been incomplete and the casein thus contain casein lactates, and if the precipitation has taken place at a pH lower than 4.7. The solution is prepared for the determination of pH in the following manner: into a 100 cc. flask equipped with a ground glass stopper are added 50 cc. of twice distilled boiled water and 5 grams of casein. After shaking, the suspension was allowed to stand for 30 minutes if the casein was finely ground and for two hours if it was coarsely ground. The two hour period may be adopted for all caseins with shaking from time to time, if the flask is tightly stoppered. Toward the end of the soaking period, the flask is allowed to stand and the supernatant liquid decanted into the electrode vessel. The hydrogen electrode required a longer period to attain equilibrium than the quinhydron or the antimony

electrode in which cases equilibrium was attained immediately. Equivalent results were obtained with all these electrodes as well as with brom cresol green indicator. A.H.J.

537. **Relationship of the Density in Dairy Products.** Jean Pien and G. Maurice, Laboratories of the Farmer's Union, Paris, France. Le Lait *18*, 176, 582–610 (June, 1938).

Equations are developed from which the density of various dairy products can be calculated from a knowledge of the density of fat and solids-not-fat in the dairy product. A.H.J.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

538. **The Progress in Italy in the Fabrication of Synthetic Fibres Derived from Casein.** G. Genin, Engineer E.P.C., Paris, France. Le Lait *18*, 175, 481–484 (May, 1938).

Caseins originating from different sources are blended in proportions to give a uniform starting material. Water and other substances are then added and a viscous paste is formed. The fibres are formed by forcing the paste through holes 0.02 to 0.03 mm. in diameter. The casein fibres are coagulated and hardened by passing them through warm sulphuric acid. The acid in the fibres is then neutralized by immersion in an alkaline bath after which the fibres are cut into small bits which form the "flocks." The small branchlets are then immersed in a formaldehyde bath in which they remain for 10 to 15 hours. After washing and drying, the product is ready for spinning and weaving. The chief difference between the chemical composition of natural and synthetic wool is the sulphur content. The casein wool has a much lower sulphur content. It consequently is a superior insulating material than natural wool. Synthetic wool fibres when boiled with water for 3 hours did not lose weight. When boiled in an alkaline soap solution there was a small loss in weight, but less than that lost by treating genuine merino wool in the same way. Fibres are also made with mixtures of casein and cellulose (viscose used in the manufacutre of rayon) materials. It is suggested that such products be called "Serinlaine" when the percentage of casein is greater than the percentage of cellulose and "Rayonlaine" when the percentage of casein is lower than that of cellulose. The nitrogen content indicates the proportion of cellulose and casein in such products. A.H.J.

Other abstracts of interest are 536, 558 and 559.

DISEASE

539. **The Effect of Subclinical Mastitis on the Solids-Not-Fat Content of Milk.** S. J. Rowland and M. Zein-el-Dine, Department of Agri-

cultural Chemistry, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 182–184, 1938.

The solids-not-fat content (expressed as percentage of the fat free milk) was determined for 247 samples of milk from individual quarters of 62 cows. The samples were also examined bacteriologically for the presence of *Streptococcus agalactiae.* Eighty-eight per cent of the samples below 8.80 per cent solids-not-fat were from infected quarters. S.T.C.

540. The Casein Number. A Chemical Method of Diagnosis of Mastitis. S. J. Rowland and M. Zein-el-Dine, Department of Agricultural Chemistry, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 174–181, 1938.

Additional data on the accuracy of the casein number

$$\left(\frac{\text{percentage of casein N}}{\text{percentage of total N}} \times 100\right)$$

as a chemical method for the detection of mastitis are reported. The number was determined for 247 samples of milk from the individual quarters of 62 cows, and the samples were examined bacteriologically for *Str. agalactiae.* For the diagnosis of mastitis from the casein number, a figure of 78.0 and less was taken as indicating an infected quarter. The chemical results differed from the bacteriological for 21 out of a total of 243 quarters. The casein number was considered from this data to be a reliable diagnostic method. S.T.C.

541. The Incidence of Mastitis in Cows Yielding Milk Low in Solids-Not-Fat. A. S. Foot and P. M. F. Shattock, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 166–173, 1938.

An average of 19.5 per cent of the animals in milk in twenty-nine herds comprising 934 cows were found to yield milk low in solids-not-fat (below 8.5 per cent) as determined by analysis of the milk from two consecutive milkings at 5 to 6 week intervals during the first three months of 1937. Of the low solids-not-fat cows which were not stale, evidence of mastitis infection was found in an average of 61.5 per cent of cases. Evidence of mastitis infection was based on physical examination, positive brom-cresol test or bacteriological examination for the presence of *Str. agalactiae.* There were apparently at least twice as many subclinical cases of mastitis as clinical cases. S.T.C.

Other abstracts of interest are 542 and 560.

FEEDS AND FEEDING

542. Reproduction on Rations Free from Vitamin E. Byron H. Thomas

AND C. Y. CANNON, Iowa State College. Proc. Amer. Soc. Animal Prod. *30*, 59–63, 1937.

A suitable grain mixture and alfalfa hay were depleted of Vitamin E by treatment with an ether solution of ferric chloride and fed to goats in the proportion of 2:1. Over a period of 4½ years both males and females reproduced normally. These same feeds fed in various proportions to rats invariably produced symptoms characteristic of Vitamin E deficiency in this species. G.C.W.

543. Phosphorus Deficiency in Cattle as a Result of Conditions Other than Low Phosphorus Content of the Soil and the Feeding Stuffs Grown Thereon. E. B. FORBES AND S. R. JOHNSON. Proc. Amer. Soc. Animal Prod. *30*, 340–344, 1937.

Reports on a survey of cattle suffering from phosphorus deficiency in Pennsylvania with a description of environment, symptoms, and methods employed in bringing about recovery. G.C.W.

544. Lactic Silage with a Pasteurized Thermophile. CONSTANTINO GORINI, Milan, Italy. Le Lait *18*, 177, 673–681 (July, August, 1938).

Satisfactory silages are high in lactic acid, unsatisfactory silages are high in butyric acid. Lactic acid fermentations in silage are usually the result of proper conditions and temperature of the silage and absence of air. A more certain method of preparing satisfactory silage is to seed with a lactic acid producing organism. A Thermophile capable of producing lactic acid is recommended. In order to prepare silage with this organism, it is necessary to compress the silage uniformly and to control the temperature so that it rises to about 60° C (140° F) neither too slowly nor too rapidly. Silage prepared in this manner is eaten readily by cattle, and is green and fresh in appearance with a minimum of wilted and faded leaves. Such silage is usually high in vitamin content as it can be prepared from freshly cut material and can be taken from the fields wet with rain or dew. A.H.J.

545. The Preservation of Fodders by the Addition of Acids. JOEL AXELSSON, Upsala, Sweden. Le Lait *18*, 172, 216–220 (February, 1938).

The use of hydrochloric and sulphuric acids or mixtures of these acids (A. I. V. process) is more satisfactory for preserving silage than organic acids. Silage preserved with these mineral acids shows lower losses in nutritive ingredients during storage, is higher in its vitamin A content, and stimulates milk production. Legumes require more acid when made into silage than do grasses. The pH of acidulated silage should be 3.5 to 4.0. The use of acid operates to soften the woody tissues of the silage and

renders them more readily digestible. The flavor of milk from cows fed acidulated silage is equal to that of summer milk and the butter is also improved. However, such milk was not satisfactory for the production of Emmenthal cheese, but was excellent for the production of sharp flavored cheeses.

A.H.J.

Other abstracts of interest are 554, 557 and 560.

FOOD VALUE OF DAIRY PRODUCTS

546. **Stability of Vitamin D in Irradiated Evaporated Milk.** C. H. KRIEGER AND H. T. SCOTT, Wisconsin Alumni Research Foundation, Madison, Wis. Food Research *3*, 3, 283, May–June, 1938.

There is little or no loss in the vitamin D potency of irradiated evaporated milk stored under average conditions for periods of two to three years, no loss whatsoever being noted after one year of holding.

F.J.D.

547. **The Effect of Commercial Sterilization on the Nutritive Value of Milk.** S. K. KON AND K. M. HENRY, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England, with the collaboration of E. W. IKIN, National Institute for Research in Dairying, Univ. of Reading, A. E. GILLAM, Univ. of Manchester, Manchester, England, AND P. WHITE, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 185–207, 1938.

V. The Effect of Commercial Sterilization on the Nutritive Value of Milk, K. M. Henry and S. K. Kon.

Fifteen samples of raw and fifteen samples of commercially sterilized milk from the same bulk were analyzed for vitamin C by the chemical method (titration with dichlorophenol-indophenol). The raw milk contained an average of 1.83 mg./100 ml. of total (reduced and reversibly oxidized) ascorbic acid. The corresponding figure for sterilized milk was 1.03 mg./100 ml., a loss of 43 per cent of the original value.

VI. Comparison of the Total Nutritive Value of Raw and Commercially Sterilized Milks, K. M. Henry, E. W. Ikin and S. K. Kon.

Paired feeding experiments with rats indicate that the total nutritive value of commercially sterilized milk is somewhat lower than that of raw milk and that vitamin B_1 is the first limiting factor. Rats getting limited but equal amounts of milk in addition to a basal diet which applied only protein, energy and minerals grow better on raw than on sterilized milk. The addition of 5 per cent brewer's yeast to the basal diet corrected this deficiency.

VII. Conclusions. S. K. Kon.

From the nutritional aspect sterilized milk has been shown to be inferior to raw or to pasteurized milk. Sterilization decreases slightly the biological value of the proteins, destroys half the vitamin C and 30 per cent of the vitamin B_1. S.T.C.

548. Groups of Milk. R. Dujarric dela Riviere and N. Kossovitch. Le Lait *18*, 474–481 (May, 1938).

Human milks contain α and β agglutinins for human red blood cells. Human milks may also be classified into 4 groups analogous to those of blood. The presence of iso-agglutinins is less regular in mother's milk (80.9% of the cases) than in their blood serum. The percentage of cases where iso-agglutinins are present in the milk is appreciably analogous for all groups (A:83.8; O:83.1). However, the percentage of group B is slightly higher (86.3). Mother's milk derived from the blood group AB (cases where the blood serum does not possess agglutinins) do not contain agglutinins; the red globules of group O (which are poor in agglutinogen) are never agglutinated by a lacto serum. The milk of group O$\alpha\beta$ always possesses the two agglutinins α and β more or less strongly. Agglutinin α in general acts more strongly than agglutinin β. Divergence between the agglutinins of blood serum and the agglutinins of milk serum of the same mother had not been found. Relation between anaphylactic shock and "group" of the milk ingested or between tolerance for milk and the group of the milk ingested have not been worked out. However in 31 cases where nutritional difficulties were being experienced with milk, it was found that the blood groups of the infant were different from the milk group of the nurse. A.H.J.

549. New Aspects of Lactic Therapy. Jean Pien, Chemical Engineer, Director of the Laboratory of the Farmers Union, Paris, France. Le Lait *18*, 177, 699–711 (July, August, 1938).

Biochemical and clinical manifestations of intestinal intoxication due to harmful intestinal flora are reviewed. Milk organisms by which such situations may be corrected are discussed. Lactic therapy demands that ferments be present which can grow in the intestine, that only living organisms of strong virulence be employed, and that the numbers of living organisms in the cultures used be high. A.H.J.

550. A Physico-chemical Theory of Artificial Infant Feeding. L. Pikler, Budapest, Hungary. Le Lait *18*, 177, 681–698 (July, August, 1938).

The author discusses the changes in colloidal and ionic conditions of cows milk that takes place as a result of the various modifications that are

accorded it in making it satisfactory for infants. Among the various treatments of milk discussed are boiling, skimming, dilution with water, addition of acids, addition of alkali, addition of salts particularly calcium salts and citrates, addition of sugar, saccharose, dextrinized flour, malt, and boiled gruel of barley, rice and oats, and the addition of dried protein, of gelatin and of gums. The effects on milk of various enzymes such as rennin, lactase, pepsin, other proteolytic enzymes, and milk lipase and stomach lipase are also discussed. The effects of these additions on osmotic concentrations and properties of the proteins, particularly of the casein, are emphasized. One hundred twelve literature citations are given.

A.H.J.

ICE CREAM

551. Ice Cream Sales Index. An Analysis of Ice Cream Sales in 1938. ANONYMOUS. Special Bulletin of the Inter. Assn. of Ice Cream Mfrs., 1105 Barr Bldg., Washington, D. C., August, 1938.

Sales of ice cream for the first four months of 1938 are compared with the same four months of 1937. For the United States, the first four months of 1938 showed increased sales. In Canada the increase for the four-month period over that of the first four months of 1937 was 6.43 per cent.

The completed survey of ice cream sales for the full year of 1937 shows the gallonage to be the greatest of any year in the history of the industry.

M.J.M.

MILK

552. The Suitability of the Cremometric and the Phosphatase Tests in the Supervision of Holder Pasteurized Milk. JOHANNE E. JACOBSEN, Royal Tech. College, Copenhagen. Zeitschr. Untersuchung der Lebensmittel *71*, 515–521, 1936.

Both reactions can be used to indicate if milk has been heated to 62–63° C for half an hour. The phosphatase test has certain advantages over the cremometric test: (1) Homogenization has no influence on the results; (2) it can be used also on cream and skimmilk; (3) a small admixture of raw milk to pasteurized milk can be detected. However, in certain respects the cremometric test is to be preferred: (1) It does not use expensive and poisonous chemicals; (2) it is so easy to carry out that any dairy can use it; (3) finally it shows if the milk has been overheated. J.C.M.

Author's Note: The cremometric method is not used in the United States as it depends upon cream layer reduction at temperatures higher than those required in the United States. In Denmark milk is generally heated to 62° C (145.4° F.) or higher.

553. How Can the Cities Be Supplied with Good and Cheap Milk. S. ORLA-JENSEN, Royal Tech. College, Copenhagen. Maelkeritidende *50,* 157–165, 1937.

The author advocates the double safeguard offered by compulsatory pasteurization, *e.g.,* 63° C., 30 min. and vigorous veterinary control of all market milk; also cream should be pasteurized. Specially to be recommended is the pasteurization in bottles, already practiced in about 400 smaller dairies in Denmark. The bottled milk should not be distributed by each individual milk company, but by a centralized distribution agency in order to cut down the cost of distribution. J.C.M.

554. Variations in the Protein Content of Milk During Lactation. E. AZARME, Institute of Animal Genetics, Univ. of Edinburgh, Edinburgh, Scotland. Jour. of Dairy Research *9,* 121–146, 1938.

The total protein nitrogen and the casein nitrogen were determined in about 380 weekly samples of milk taken from twenty-seven individual cows of different breeds and at different stages of lactation during a period of about 6 months. The albumin plus globulin nitrogen was calculated in each case by difference. It was found that the percentage of total protein nitrogen decreases very significantly from the beginning until the 4th week of lactation, and then rises slowly until the end of lactation, the rise being more pronounced towards the end. The same was true for casein nitrogen and for albumin plus globulin nitrogen, but with the latter only the decrease at the beginning and the rise at the end was sharp. S.T.C.

555. The Milk of the Goat under English Conditions. FRANK KNOWLES AND J. E. WATKIN, East Anglican Institute of Agriculture, Chelmsford, England. Jour. of Dairy Research *9,* 153–165, 1938.

An account is given of observations made for over two years on the yield and composition of the milk of the breeds of goats distributed throughout Great Britain. In all 2662 samples from 345 animals of 8 breeds were analyzed. The average analyses reported are as follows: fat, 4.50 per cent; solids-not-fat, 8.68 per cent; lactose, 4.08 per cent; total proteins, 2.90 per cent; casein, 2.47 per cent; albumin and globulin, 0.43 per cent; non-protein nitrogen, 0.44 per cent; ash, 0.79 per cent. The average milk yield of the officially recorded goats in Great Britain was shown to be about 7½ pounds per day. S.T.C.

556. The Milking Pail of Jens Grand. S. ORLA-JENSEN, Royal Tech. College, Copenhagen. Maelkeritidende *50,* 1039–1041, 1937.

The practice of milking directly down upon solid carbon dioxide to cool milk effectively has not been found to have any value. Such large quantities

of CO_2 are needed that the milk gets a disagreeable flavour. The bacteria present are not inhibited under these conditions, some are even favoured in their development.

The value of filling milk pails with gaseous carbonic acid is thus open to doubt. The favorable results obtained with the device of Jens Grand are probably caused by the careful sterilization and handling of the apparatus and not by the presence of CO_2. J.C.M.

557. **Errors Involved in the Estimation of the Lactation Yield of Protein According to the Intervals between Sampling.** E. Azarme, Institute of Animal Genetics, Univ. of Edinburgh, Scotland. Jour. of Dairy Research *9*, 147–152, 1938.

An attempt was made to determine the frequency of sampling necessary to estimate accurately the lactation yield of protein. For practical purposes sampling every two weeks during the first 6 weeks and the last 4 weeks of the lactation and every three weeks for the remainder was considered sufficient. S.T.C.

Other Abstracts of interest are 522, 523, 524, 537, 539, 541, 546, 547, 548, 550, 558, 559, 560.

MISCELLANEOUS

558. **Problems which Remain to Be Solved in the Dairy Industry.** G. Genin, Chemical Engineer E.P.C., Paris, France. Le Lait *18*, 176, 610–614 (June, 1938).

Problems dealing with the production of fluid milk, condensed milk, ice cream, cheese, the fabrication of dairy equipment, and the disposal of dairy wastes are discussed. A.H.J.

559. **Treatment of Waste Water from the Dairy.** G. Genin, Engineer E.P.C.I., Paris, France. Le Lait *18*, 177, 711–714 (July, August, 1938).

Loss of milk in the wash water of the dairy averages $\frac{1}{2}$ to 1% of the milk passing through the plant. For cheese factories and creameries the losses run from 3% to 8%. Such losses in the dairy wastes going into streams are responsible for considerable pollution. Rather than require expensive waste disposal plants, it is suggested that efforts be made to keep concentrated wastes from going into the wash water. This may often be done inexpensively by modifying existing equipment or processes and by exercising care in the saving of possible usable dairy wastes and in the cleaning of equipment. A.H.J.

PHYSIOLOGY

560. Secretion of Milk. DWIGHT ESPE, Iowa State College, Ames, Iowa. Published by Collegiate Press, Inc., Ames, Iowa. Price $3.00.

This book was designed as a text for a course in Milk Secretion in which the principal objective is the application of the fundamental training received by the student in Anatomy, Physiology, and Nutrition to the problems dealing with the normal functioning of the mammary gland.

The material covered is well organized into three parts. Part one deals principally with the anatomical aspects of the subject, part two with the physiological, and part three with the nutritional.

The subject matter is clearly presented and should be found readable by those for whom the book is intended. This work provides a much needed text and reference work for the undergraduate student in dairy production.

The author has used a wealth of reference material and a bibliography of 695 references is appended. While the book was not designed for the research worker, the generous use of the literature makes this a useful book for the library of the investigator.

The author has made generous use of illustrative and tabular material, there being forty-nine illustrations and thirty-four tables. T.S.S.

Other abstracts of interest are 539, 541, 554, and 557.

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// JOURNAL OF DAIRY SCIENCE

VOLUME XXI DECEMBER, 1938 NUMBER 12

SULFANILAMIDE IN THE TREATMENT OF STREPTOCOCCIC MASTITIS*

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INTRODUCTION

Much interest is being shown at the present time in the use of sulfanilamide in the treatment of streptococcic mastitis of cattle. In the published reports to date, variable results have been obtained by the use of this drug. These facts indicated that further study of this problem should be made.

REVIEW OF LITERATURE

Domagk (4) in 1935 first reported the favorable effect of certain Azo dyes in mice experimentally infected with streptococci. The name ''sulfanilamide'' was later given to the essential nucleus or effective portion of these dyes by the American Medical Association. Numerous results on the use of sulfanilamide in human medicine have been reported.

Very few controlled experiments with the use of this drug in streptococcic mastitis of cattle have been reported. Allot (1) in November, 1937, reported both clinical and laboratory evidence of improvement in three cows treated with approximately the dose recommended for man, that is, 1 gram for each 20 pounds of body weight. In each instance the case relapsed to approximately its previous condition after treatment was discontinued. Several case reports found in Cattle Breed Journals and Biological Journals have reported favorable results from the use of this drug in doses of 15 to 45 grains (15 grains = 1 gram) 2 to 4 times daily for 3 to 7 days.

Baer and Gunderson (2), reporting on the use of sulfanilamide in the treatment of mastitis, state that streptococci did not appear during treatment but were present after treatment was discontinued on two cows and that streptococci were reduced following treatment on two other cows.

Scholm (8) reported on four cases of streptococcic mastitis treated with sulfanilamide at the California Veterinary Conference, January, 1938.

Received for publication June 6, 1938.

* Published with the approval of the Director of the Idaho Agricultural Experiment Station as Research Paper #170.

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These represented slight, moderate, severe and very severe cases of mastitis. The cows averaged approximately 900 pounds each and were first treated with 120 to 150 grains (8 to 10 grams) of sulfanilamide in two equally divided doses daily. The only case that showed any improvement was the one showing slight evidence of mastitis. After a 7-day rest period, the four cases were again treated for 7 days with sulfanilamide in 2 equally divided doses, with the mild case receiving 80 grams daily and the other 3 cases 40 grams daily. The streptococci disappeared from the milk of all quarters in the mild case and from 3 quarters of the moderate case and were reduced in number in the severe and very severe cases. Two weeks after treatment streptococci were again present in all quarters of all the cows treated. No symptoms of intoxication were observed in any of the cows.

Schlotthauer (9) reported on the treatment of one cow for streptococcic mastitis with sulfanilamide at the Intermountain Livestock Sanitary Association meeting in January, 1938. He stated that one 900-pound cow was treated for 3 days with 90 grains (6 grams) daily and showed 1 mg. of the drug in 100 cc. of the milk. She was then treated with 44 grams daily for 4 days. In the neighborhood of 8 hours after the last dose, she showed 5.6 mg. per 100 cc. of the milk. The highest per cent of the drug was found in the normal quarter and much less, or about 1 mg. per 100 cc., in the inflamed quarter. In both treatments there was inhibition of the organisms in the udder but they were not destroyed.

Recently Johnson and Miller (5) have reported on the use of 75 grains (5 grams) of sulfanilamide twice daily for 3 days on 6 cows and ½ ounce (14 grams) twice daily for 8 days on 4 cows afflicted with chronic streptococcic mastitis with no apparent beneficial effects from the treatment. No toxic effects were produced by the treatment.

PURPOSE OF INVESTIGATION

The study at the Idaho station was started in June, 1937, before the above reports were presented, and because of the absence of accurate data then available it seemed advisable to study the following points:

1. To determine how often it would be necessary to administer sulfanilamide to cattle to maintain a reasonably constant level in the blood.
2. To find what dose is necessary to attain a blood concentration in cattle comparable with that obtained in man.
3. To establish the degree of effectiveness of the treatment in streptococcic mastitis, and
4. To determine what unfavorable results, if any, follow its use.

Streptococcic mastitis has been studied in this station herd for the past ten years. During the past fall and winter, a particularly virulent form of the disease has been prevalent. Heifers showing their first clinical symptoms drop in milk production and go off feed. Difficulty is experienced in getting the affected quarters back to normal with past methods of treatment.

DOSE INTERVAL TO MAINTAIN BLOOD LEVEL

In this work, "Stramid," a brand of sulfanilamide marketed by the Alba Pharmeceutical Company, was used. In every instance the material was given by mouth in gelatin capsules. The concentration of unconjugated sulfanilamide in the blood and urine was determined by the method recommended by Marshall, Emerson and Cutting (6). The Marshall, Emerson and Cutting method was adapted to the determination of the concentration of unconjugated sulfanilamide in the milk.

Two cows were used in this phase of the study. A Jersey cow, #107X, was given 5 grams of sulfanilamide for each 100 pounds of body weight. Blood, urine and milk samples were taken at hourly intervals following this dosage and the sulfanilamide concentration determined. Similar data were also taken on a Holstein cow #55X following the last dosage of a 7-day period of treatment. In both instances it was found that sulfanilamide

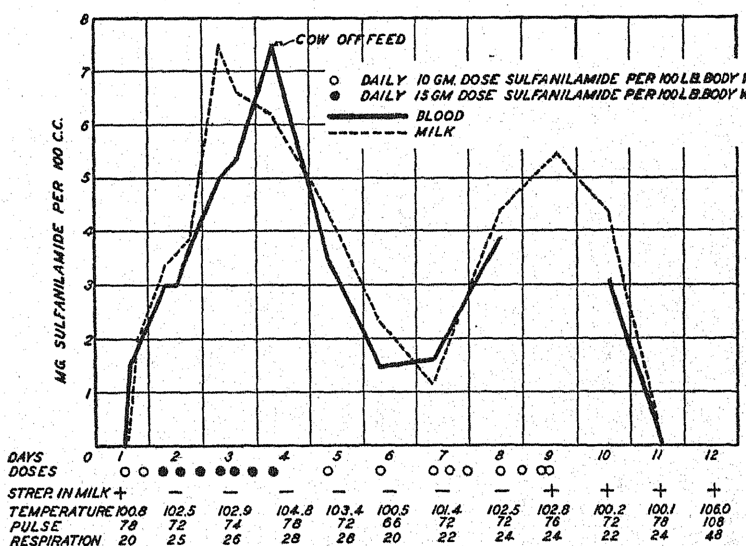

FIGURE 1. Cow #8X. This graph shows the variations in doses given, the fluctuations in the blood and milk levels of sulfanilamide. The presence or absence of hemolytic streptococci in the milk and the effect of the treatment on the temperature, pulse and respiration are also shown. The cow showed symptoms of sulfanilamide poisoning when the blood concentration was between 7 and 8 mg. per 100 cc. This cow died showing cynosis of the voluntary muscles the day following the last shown in the table.

concentration in the blood did not start to drop until about 12 hours after the last dose was administered. Seldom was sulfanilamide detected in the blood or milk 48 hours after the last dosage (See Figures 1 and 2).

The greater persistence of blood level of sulfanilamide in cattle than in man is not surprising, since in ruminants the transfer of material from the rumen is slow, allowing the drug to be presented slowly for absorption

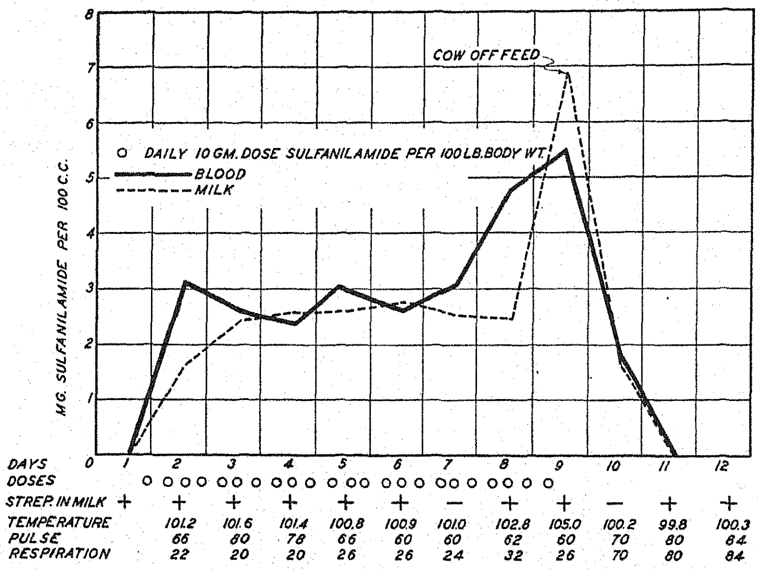

FIGURE 2. Cow #89X. This shows the general level of sulfanilamide in the blood and milk when a cow receives 10 grams per 100 pounds body weight daily. On the last day of treatment the cow showed symptoms of intoxication. At this time the blood level was about 5.5 mg. and the milk level just under 7 mg. per 100 cc.

to the small intestines. This study would indicate that it was not necessary to repeat the dose of sulfanilamide more often than every 12 hours or twice daily.

BLOOD LEVEL IN RELATION TO DOSE

In the initial trial, where the dosage was at the rate of 5 grams of sulfanilamide to 100 pounds of body weight daily, the blood and milk level remained slightly below 2 mg. per 100 cc. The drug was administered in three or four equally divided doses. This level was far below the 10 to 20 mg. attained in man (6). On subsequent trials, the dose was doubled and trebled that used in man; that is, 10 and 15 grams per 100 pounds body weight. Reference to Figures 1 and 2 show that with these high doses, it was possible to attain blood levels slightly below 8 mg. per 100 cc. Cows regularly go off feed and show other clinical symptoms of sulfanilamide poisoning before the blood level reaches 8 mg. per 100 cc. From this study it would seem impossible to attain blood levels in cattle comparable with that attained in man. This may be due in part to the rapid excretion of this material in the urine or to the possibility of a greater conjugation of sulfanilamide in the blood of cattle.

EFFECTIVENESS OF SULFANILAMIDE IN TREATING STREPTOCOCCIC MASTITIS

Three distinct stages of streptococcic mastitis cases were treated with varying levels of sulfanilamide. Two Jersey cows (#107X and #112X)

had streptococcic infection of about 8 months' duration, one of which showed definite clinical symptoms, were treated with 10 grams per 100 pounds body weight for 7 to 10 days. Streptococci were absent from the milk during most of the period of treatment, but were detected following the termination of treatment. No. 107X had previously been treated with 5 grams per 100 pounds for 9 days without permanently eliminating the streptococci.

Failure to eliminate the causal organisms in these two cases prompted the treatment of two Holstein cows (#89X and #74X). These cows had contracted streptotoccic infection of the udder during the previous 2 months as shown by bacteriological examination of the milk. No clinical evidence of mastitis had developed in either of these cows. They were treated for 8 days with 10 grams per 100 pounds body weight. Streptococci were absent from the milk of #74X during treatment but were present in the milk of #89X. Streptococci were present in the milk of both cows continuously after the termination of treatment. Apparently sulfanilamide even in doses twice that recommended for humans is not effective in eliminating streptococci from the udder of cows affected with non-clinical streptococcic mastitis.

Several cases of acute clinical streptococcic mastitis (#24X, #8X, #85X, #194, #101X, #89X, #128X, #126X, #87X, #103X, #175, and #187) some of which were flare-ups of old chronic cases and others of recent infection were treated with 5 to 10 grams of sulfanilamide per 100 pounds of body weight for periods of 7 to 10 days. Most of these cases had been treated with hot packs, frequent milking, udder ointments, massage, and mild laxatives without eliminating the tendency for the milk to become watery or thick with pus. In some instances the fever, swelling and hardness in the affected quarters were practically eliminated by this standard treatment.

By the end of the sulfanilamide treatment, all cases except one were showing improvement in the consistency of the milk, although many of them were deficient in quantity of milk from the affected quarters.

Treatment with sulfanilamide was successful in restoring normal flow and normal appearance in the milk and the quarter if administered in the early stages when the first symptoms of flaky milk and congestion of the quarter appear. It did not eliminate the streptococci from the udder, nor prevent later acute attacks. This treatment, however, apparently saved many quarters which otherwise would have been lost by reducing the acute infection before the quarter was permanently injured.

Treatment was also effective in restoring normal appearance to the milk of recently infected cows when the condition had developed to the stage where the milk was discolored and watery. However, in these severe cases the affected quarters shrunk to half the normal size and the milk flow was reduced about 50 per cent. One exception to the above (#103X)

showed only partial recovery and relapsed to the previous state after treatment was discontinued.

Use of sulfanilamide resulted in improvement in acute attacks of old chronic cases, but normal milk was not secured in all instances. In one case out of three the milk failed to return to normal appearance.

Five grams of sulfanilamide per 100 pounds of body weight seemed just as effective in producing favorable results as did larger doses.

TOXICITY OF SULFANILAMIDE

Sulfanilamide in doses of 5 grams per 100 pounds body weight, when administered in three equally divided and spaced doses each day over a period up to 12 days, had little or no detrimental effect in 9 of 11 cases treated. This amount did not reduce milk production.

Twice this amount, that is, 10 grams per 100 pounds body weight, after 5 to 7 days' administration, is sufficient to cause distinct toxic effects in the form of general sluggishness, reduction in feed consumption, reduction in milk flow, rough coat and occasionally complete loss of appetite and increased temperature and respiration. (See Figures 1 and 2.)

Higher amounts, that is, 15 grams per 100 pounds body weight daily, for from 1 to 3 days, produce the above-mentioned toxic symptoms accompanied by a precipitate of crystals in the urine. Reduction in milk flow associated with toxic doses was commonly observed. When treatment is discontinued, the milk flow rapidly returns to normal.

One cow (#8X) died the third day following discontinuance of treatment with 10 and 15 grams sulfanilamide per 100 pounds body weight. She became foundered on not more than 10 pounds of grain, developed a diarrhea and died within 36 hours. On post mortem, the liver, spleen and kidneys appeared normal. Definite evidence of acute enteritis was present. All muscular organs were extremely cyanotic, particularly the voluntary muscles which were quite blue on dissection, but soon became normal flesh-colored when exposed to the air. This condition has been found in man associated with sulfanilamide poisoning as recorded by Bigler, Clifton and Werner (3).

One cow (#112X) which was turned out during the last three days of a 10-day period of treatment with 10 grams per 100 pounds body weight, developed an eczema with considerable loose scab production over the head, neck and shoulder and between the limbs and on the udder. The condition seemed to be most severe where there was contact with the stanchion. A similar condition is common in man as reported by Newman and Sharlit (7) when individuals being treated with sulfanilamide are exposed to the direct rays of the sun.

One cow (#126X) died of bloat while on treatment with 5 grams per 100 pounds body weight. She had shown no symptoms of sulfanilamide poison-

ing and did not show any post mortem evidence of poisoning. She is believed to have died of simple bloat.

SUMMARY

1. The blood and milk levels of unconjugated sulfanilamide in cattle were maintained over a period of 12 hours either following an initial dose or after the last dose of a period of treatment. This insures a reasonably constant level of sulfanilamide in the blood of cows that are dosed twice daily at 12-hour intervals.

2. It was possible to attain a level of sulfanilamide in blood and milk slightly under 8 mg. per 100 cc. only when the dose was approximately 10 grams per 100 pounds body weight or twice that recommended for man. Blood levels slightly less than 2 mg. per 100 cc. were attained with a dose comparable with that recommended for man, that is, 5 grams per 100 pounds body weight daily. Both of these levels are below that of 10 mg. per 100 cc. of blood suggested for favorable results in man.

3. Doses of 5, 10, or even 15 gm. per 100 pounds body weight over a period of 3 to 10 days failed to permanently eliminate Beta Hemolytic Streptococci from the udders of cows affected with streptococcic mastitis, regardless of whether the cases were acute or chronic or of short or long duration. Even recently affected non-clinical cases were not freed of the organism.

4. Symptoms of acute streptococcic mastitis such as tenderness, swelling, hardness of the quarter, accompanied by flaky, pussy, or watery milk were relieved in most cases by administering sulfanilamide in doses of 5 to 10 grams per 100 pounds body weight for 7 to 10 days. Five grams per 100 pounds body weight seemed to be as effective as larger doses in relieving clinical symptoms of acute mastitis. The cases treated had failed to respond satisfactorily to the standard treament of applying hot packs, frequent milkings, massages, laxatives and udder ointments.

5. Sulfanilamide poisoning in the form of sluggishness, loss of appetite, reduced milk flow, roughened coat, fever and increased pulse and respiration were produced in 1 to 3 days when the total daily dose was 15 grams per 100 pounds body weight. Five grams per 100 pounds body weight had little or no detrimental effect in 9 of 11 cows treated. The dose should be reduced or eliminated when toxic symptoms appear.

6. One cow died following doses of 10 and 15 grams per 100 pounds body weight with enteritis diarrhea and definite cyanosis of the musculature. Another cow showed extensive eczema when allowed contact with the direct rays of the sun during treatment with 10, and later 5, grams per 100 pounds body weight. There seems to be an individual difference in tolerance of cows to sulfanilamide.

7. Sixteen cows were treated for streptococcic mastitis with sulfanilamide. Eight of nine cases with an initial infection showing acute symptoms gave favorable results with a reduction of inflammation of the udder and restoration of normal-appearing milk. One cow showed symptoms of toxic poisoning and treatment was discontinued. Favorable results were obtained in 6 out of 9 severely affected quarters in 4 old chronic cases. The 3 additional quarters were greatly improved. No improvement was shown in three cases of initial infection where clinical symptoms had not developed.

The bacteriological and chemical phases of this study were conducted with the cooperation of Walter G. Hoge, W. V. Halversen, and V. A. Cherrington of the Department of Bacteriology, University of Idaho. A report covering this phase of the study in more detail will be published as Research Paper No. 169.

Note: Individual case histories of cows treated in this study are available to anyone upon request to the authors.

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AN X-RAY DIFFRACTION ANALYSIS OF CASEIN

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HISTORICAL INTRODUCTION

X-Ray Studies of Protein Structure

The purpose of x-ray analysis is to determine the arrangement of diffracting units within a crystal unit and to interpret the properties of that crystal in terms of that arrangement. Proteins, in general, are not crystalline in structure, according to Astbury and Lomax (1), and, consequently, typical crystalline effects are not registered on a photographic film when they are subjected to x-ray analysis. Meyer and Mark (2) were the first to apply the principles deduced from the structural arrangement of cellulose to their interpretation of the protein pattern of fibroin. At that time they suggested that fibroin was made up of extended polypeptide chains, built for the most part of alternating glycine and alanine residues. This type of structure has been confirmed for fibered proteins by Astbury (3) who has studied the protein keratin from a number of different sources and under a wide range of conditions. Astbury found that hair keratin existed in two structural forms. The pattern for stretched hair, or beta keratin, could be explained in terms of extended polypeptide chains, whereas the pattern for the unstretched hair or alpha keratin was one of random arrangement. Therefore, this indicated that the chains were in a crumpled state.

Non-fibrous proteins give patterns that cannot be used as successfully for unit cell structure determination as can patterns obtained from fibered proteins. Casein is not a fibered protein, according to Svedberg, Carpenter, and Carpenter (4), but exists as small particles almost spherical in shape. The particle size was detemined by Svedberg (4) by calculation from specific sedimentation velocity data using Stoke's law, under the assumption that the particle was spherical. The value for radius is $(r) = 4.177 \times 10^{-7}$ cm. (41.77 Å). Using the diffusion constant and Einstein's law, particle size was also determined when no assumption was made as to the shape of the particle. The value for r was then found to be $r = 5.994 \times 10^{-7}$ cm. (59.94 Å). The ratio between the two values of rE/rS equals 1.43 and this figure agrees well with the values for hemoglobin, serum albumin, and serum

Received for publication June 3, 1938.

* The data presented in this paper are from a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the degree of Doctor of Philosophy, 1937.

globulin that had been determined previously by Svedberg and are known to be non-fibrous.

At times difficulty in interpreting the physical properties of casein and compounds of casein has been encountered. Recently x-ray analysis has been applied to research in the biological fields where valuable contributions have been made by this technique to the knowledge of the structure of certain proteins. In undertaking this study it was considered that x-ray analysis would yield information that could be secured in no other way. If changes in structure of the casein molecule could be correlated with definite treatments, then possibly the properties of this compound could be accounted for by the molecular arrangement.

EXPERIMENTAL PROCEDURE

Methods for Casein Preparation

Pure casein was prepared according to the method of Van Slyke and Baker (5). Although Svedberg, Carpenter, and Carpenter (6) have shown that casein prepared by the Van Slyke and Baker method does not correspond in molecular weight with casein prepared by Hammersten's procedure, nevertheless their results show that casein prepared by either method is a mixture of protein molecules of varying molecular weights. The main constituent of Van Slyke's and Baker's casein, according to Svedberg (6), corresponds to a molecular weight of 100,300, whereas approximately one-third of the casein prepared by Hammersten's method has a molecular weight of 375,000.

Casein was also prepared by hydrochloric acid precipitation from fat-free milk by adjustment of the pH to 4.6. Casein products prepared by rennin coagulation, ultra-filtration, ultra-centrifuging, and electric deposition were also used.

Various addition compounds of casein were prepared from the Van Slyke-Baker casein. The following chemicals were used for their preparation: $NaOH$, Na_2CO_3, NH_4OH, $Na_2B_4O_7$, and 40 per cent formaldehyde. The procedures followed were those published by Sutermeister (7).

X-Ray Analysis

For x-ray analysis the usual diffraction technique was used. X-rays were generated in a Philips metallix type tube, using a copper target. The majority of exposures were taken when the tube was being operated at 35 KV and 25 Ma. X-rays from an iron target were also tried. The tube was then operated at 18 KV and 15 Ma. The powder method of Hull, Debye, and Scherrer was used with the sample mounted directly in front of the .025 inch lead pin hole. The exposures lasted from 3 to 6 hours. Each pattern was registered on a flat film held in a casette 5 cm. from the sample. Figure 1 illustrates, by a diagrammatic drawing, the laboratory technique that was

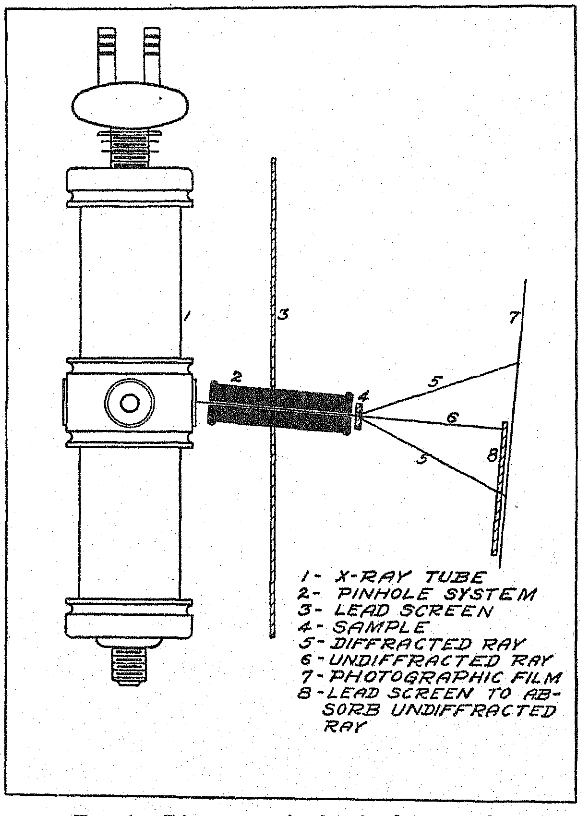

FIG. 1. Diagrammatic sketch of x-ray tube.

used for the x-ray diffraction analysis of the substances studied. The same diffraction pattern was obtained regardless of whether a thin sample (.1 to 1 mm.) of dried casein was used or whether the sample was first ground to a powder with mortar and pestle. When the materials were not dried broad diffuse halos were obtained instead of the characteristic pattern of the dried casein samples.

Interpretations of the powder patterns obtained from the various substances were made by the use of the Bragg equation, $n\lambda = 2d \sin \theta$. The radii of the diffraction rings were determined and then by appropriate calculations and substitution in the above equation the "d" values, or distances between diffraction units or planes, were calculated. The "d" values are specific and characteristic for each substance. This technique, therefore, serves as a ready means for analysis and identification of materials.

EXPERIMENTAL RESULTS AND DISCUSSION

X-Ray Diffraction Analysis of Casein

Pure casein, made by the Van Slyke and Baker (5) method, was the first

to be subjected to x-ray analysis by the pin-hole method. Following this, caseins made by the procedures previously described were analyzed. The diffraction patterns obtained from each of these products had two halos characteristic of complex proteins whose component groups are apparently not arranged in a geometric fashion, but whose arrangements are entirely ones of random. Although Figures 2 and 3 illustrate only the patterns ob-

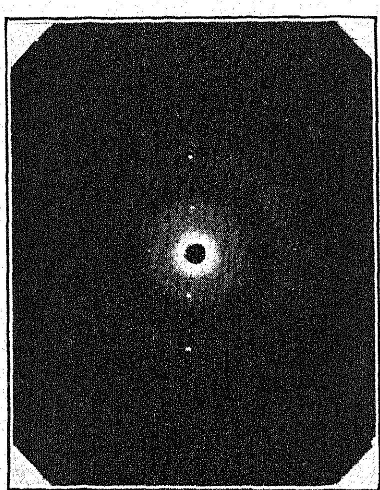

FIG. 2. Pure casein.

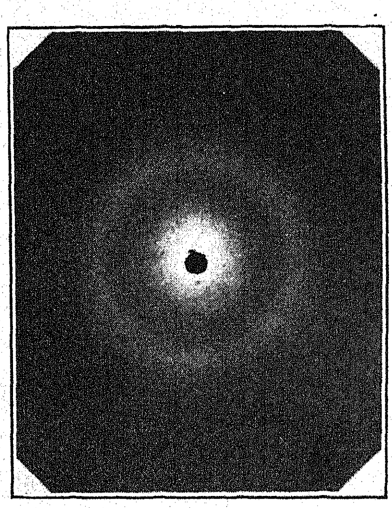

FIG. 3. Casein coagulated by rennin.

tained from pure casein and casein coagulated by rennin, the patterns from the other caseins are almost identical. The calculated spacings for d_1 and d_2 of these caseins are of the same order of magnitude, which is evidence of their similarity. The values are listed in the following table.

TABLE 1

Spacing values for caseins

Spacing	Pure casein Van Slyke and Baker	Crude com. casein ppt. by HCl	Casein coagulated by rennin	Casein from ultra filter	Casein from ultra centrifuge	Casein deposited by elect. current
d_1	9.9 Å	9.8 Å	9.9 Å	9.9 Å	9.84 Å	9.7 Å
d_2	4.66 Å	4.60 Å	4.62 Å	4.60 Å	4.65 Å	4.60 Å

Although the above products were prepared by entirely different procedures the method of preparation had no marked influence on the internal arrangement and molecular structure of the caseins, as determined by x-ray diffraction analysis.

The diffraction pattern obtained from casein (1, 8) is typical of non-fibrous proteins which are without sufficient orientation or number of inter-

ferences to lend themselves readily to accurate analysis, and as a result no satisfactory solution of structure has been developed. The probable explanation of the lack of structural organization in casein and other proteins of a like nature, according to Clark and Schaad (9), is due to the mutual attraction of the large number of polar groups that probably occur in a complex protein structure. The polar groups are apparently distributed at irregular intervals in both side chains and along main chains; hence the structural design is not one of a regular geometric pattern but is one due to the chemical nature of the material.

Emil Fischer was the first to advance the hypothesis that proteins are essentially a synthesis of polypeptide chains, and since the work of Meyer and Mark (2) x-ray diffraction data of protein structure has been interpreted on the assumption that proteins are built up of polypeptide chains which are either in an extended condition, as in stretched hair, or in a crumpled state, as in unstretched hair. X-ray data, as interpreted by Astbury (10), have also shown that side chains extend from the main chain at regular intervals and these serve as definite diffraction units in determining the perpendicular distance, in the same plane, between the polypeptide chains. This spacing is exceedingly varied since it seems to depend to a large extent on the amount of water held by the protein. For the majority of proteins this value has been calculated to be from 9.5 Å to 10.5 Å, although Clark and Schaad (9) have found it to vary from 10.4 Å to 17 Å for certain proteins, depending on the amount of water bound by the protein. On the other hand, it can be seen from Table 1 that this spacing was very uniform in the different casein samples analyzed.

In addition to this 9.8 Å spacing which is always present in diffraction patterns of proteins, another one appears which represents the perpendicular distance or thickness between planes of polypeptide chains. This value is rather uniform for all proteins, being for the majority 4.6 Å. The casein samples showed no exception for this spacing, and all samples were very uniform in this spacing value. Secondary valence forces are assumed to be responsible for the holding together of the polypeptide chains in the protein grid (10, 11, 12).

In the production of the peptide linkage there is a combination of the amino group of one amino acid with the carboxyl group of another, to yield the CONH group. Apparently the alternation of CONH and RCH groups determines the repeating patterns of proteins. The characteristic identity period for silk, hair, and other proteins has been of the magnitude of 3.5 Å (10). A spacing at 3.08 Å has been found to be present in cheese but not in casein.

Although the peptide linkage seems to be the most common and prominent type of binding proteins, Abderhalden's diketopiperazine hypothesis

has been used to explain a few peculiar reactions of proteins to certain treatments and reagents.

The Reaction of Casein to Certain Alkaline Reagents

In order to determine the effect of alkalis on casein, alkaline caseinate compounds were prepared as previously described. Each of these gave the same x-ray diffraction pattern and, upon calculation, the "d" spacings were approximately the same as for uncombined casein. This would indicate, then, that the preparation of sodium caseinate glues and plastics, although bringing about decided changes in physical and chemical properties of casein, does not produce any characteristic or definite change in molecular structure. Apparently only surface reactions are involved. However, when NaOH was added to casein and the sodium caseinate heated to boiling, a marked change in color appeared. This reaction produced a decided change in the diffraction spacings, as shown in the table below. Apparently there was a tendency for shrinkage and a closer packing of the peptide linkages.

TABLE 2

Spacing values for alkaline compounds of casein

Spacing	Casein NaOH	Casein NH_4OH	Casein $Na_2B_4O_7$	Casein Na_2CO_3	Casein | NaOH Boiled
d_1	9.78 Å	9.84 Å	9.78 Å	9.80 Å	9.34 Å
d_2	4.61 Å	4.67 Å	4.62 Å	4.60 Å	4.45 Å

X-ray diffraction patterns for two of the above preparations are illustrated by Figures 4 and 5. Each shows characteristic halos of non-fibrous,

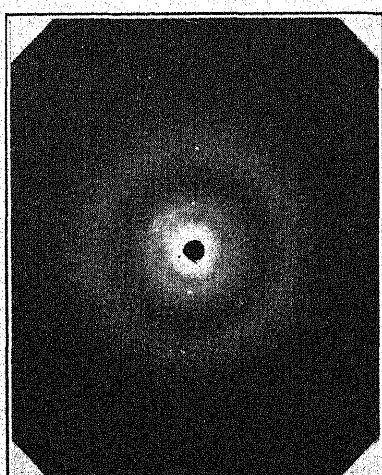

FIG. 4. Sodium caseinate (NaOH + casein).

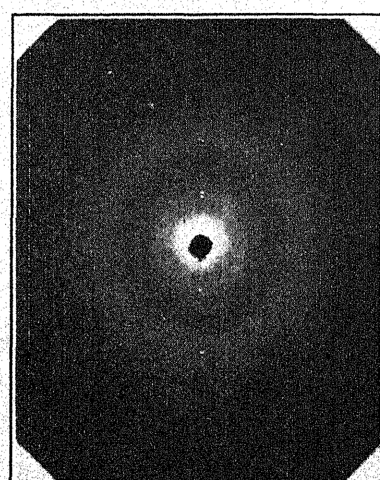

FIG. 5. Boiled sodium caseinate.

non-crystalline proteins. Astbury and co-workers (13) assert that denaturation of proteins brings about a tendency for a fibering of proteins as they are most stable and most insoluble in this condition. According to them, "the denatured state is essentially a fibered one, inasmuch as it always consists of peptide chains often fully extended and aggregated after coagulation, as in fibroin."

Although casein was denatured by boiling in strong alkaline medium, orientation could not be observed. Long threads were produced, dried under tension, and mounted either parallel with, or perpendicular to, the plane of x-rays, but no orientation was noticed. Coagulation of casein by rennin also denatures this protein. However, no fibering or orientation occurs, even though the protein is stretched into long threads.

The reaction of alkalis and acids with casein that brings about a change in the physical properties of casein but not a change in the molecular structure might be explained by assuming that proteins, in general, are amphoteric electrolytes (14). They combine with anions on the acid side of the isoelectric point and with cations on the alkaline side. The isoelectric point of casein is at pH 4.7. In making sodium caseinate the reaction occurs at pH 10, or greater. Under these conditions the reaction would occur at the COOH radical. The sodium caseinate that is formed could then dissociate into a protein anion and a Na^+ cation. On the acid side of the isoelectric point the amino group of the protein molecule behaves like ammonia in its ability to add an acid. The hydrochloride that is formed could then dissociate into a cation and a Cl^- anion. Assuming then that the casein would react as colloidal particles, there are undoubtedly numerous COOH and NH_2 groups that would react in the manner described, producing changes in physical properties but no profound molecular structural rearrangement due to the reaction.

The Reaction of Casein and Formaldehyde

The chemical reaction that occurs between casein and formaldehyde is decidedly interesting and, from an industrial viewpoint, highly valuable, for on this reaction is based the production of goods of the casein plastic industry. When a weak solution of formaldehyde (3–5 per cent) is added to a sheet of casein a hardening or denaturation reaction occurs that is solely characteristic of formaldehyde. At first, like the alkali reactions, this appears to be only a surface reaction, since the hardening occurs very shortly after the casein is in contact with the formalin solution. However, the reaction continues and proceeds at a more or less constant rate, according to Henley (15). This investigator worked with serum proteins and found that the formol reaction was of the second order; that is, for a given reaction to occur, the time required is inversely proportional to the original concentration. Although the reaction of formaldehyde on casein rapidly alters

the physical properties of the casein, no marked internal change in structure occurs. However, at the end of five days in 40 per cent formalin a sample of ultra-filter casein showed a new strong diffraction interference that is characteristic of the reaction of formaldehyde and casein.

It was first considered that the presence of the new diffraction interference would aid in interpreting the casein formaldehyde reaction, but further work showed this new line to be due to polymerized formalin that had crystallized in the casein during the reaction (16).

Although formalin produces decided physical changes in casein, it has not been possible by x-ray diffraction analysis, as yet, to show marked molecular structural changes, occurring as a result of the reaction.

SUMMARY

By x-ray diffraction analysis an attempt has been made to interpret changes that were produced by the action of acids, alkalis and formaldehyde on casein, as well as, attempting to distinguish differences in casein prepared by various methods.

No marked differences were found in the casein samples prepared by various procedures. Only by vigorous boiling in the presence of NaOH were marked changes in structure observed due to chemical treatment.

The two halos produced by casein upon x-ray diffraction analysis were typical of non-fibrous proteins. The halos were at spacings of approximately 4.6 Å and 9.8 Å which correspond respectively to the vertical distance between layers of polypeptide chains and the longitudinal distance of side chains from the main chain. These values agree well with other non-fibrous proteins that have been subjected to x-ray analysis.

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AN X-RAY DIFFRACTION ANALYSIS OF CHEDDAR CHEESE

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INTRODUCTION

The determination of chemical changes occurring in cheddar cheese during ripening has been the subject of research by numerous investigators.

Van Slyke and Hart (1) in 1902 considered the first step in cheese ripening was the peptic digestion of paracasein. They found that as the cheese aged there was an increase in water soluble nitrogenous products.

Later these same investigators (2) studied the individual proteolytic compounds liberated from the aged cheddar cheese. After 214 days at 15.5° C. (60° F.) they found that 15 grams of CO_2 had been liberated, which was .5 per cent of the weight of the fresh cheese. In addition, tyrosine, oxyphenolethylamine, arginine in traces, histidine, lysine, guanidine, and putresine in traces were also identified as hydrolytic products of cheddar cheese ripening.

Kelley (3) showed that the protein of cheddar cheese is hydrolyzed at a fairly uniform rate, and that at 90 days approximately 20 per cent of the protein was water soluble.

Lane and Hammer (4) in studying the rate of protein hydrolysis in cheese made from raw milk, and cheese made from pasteurized milk, concluded that cheese made from raw milk ripened more rapidly as measured by protein hydrolysis.

The purpose of the present investigation was to study the chemical changes occurring in cheddar cheese, both by chemical analysis and by the x-ray diffraction technique.

EXPERIMENTAL PROCEDURE

X-Ray Diffraction Analysis

The procedure followed in securing the x-ray patterns of the experimental samples has been described in the preceding paper.

The cheese samples used for diffraction analysis were prepared by cutting a thin slice of the cheese approximately .5 mm. thick and then drying it at 37° C. for 12 to 24 hours. The samples were then washed with ether

Received for publication June 3, 1938.

* The data presented in this paper are from a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the degree of Doctor of Philosophy, 1937.

to remove the ether soluble material. When cheese samples were not dried, broader and less sharply defined rings were obtained. When the fat was not removed by ether extraction, lines due to liquid fat were obtained.

The pure amino acids which were used for the standard patterns in identifying the amino acids liberated in the cheese were obtained through the courtesy of Professor W. C. Rose, of the Division of Biochemistry, University of Illinois.

Methods for Chemical Analysis of Cheese

Chemical analyses of the cheeses were made after one day, one week, and at monthly intervals thereafter until the cheese was 180 days old.

The methods used and the procedure followed were much the same as those used by Kelley (3). Hydrogen ion concentration measurements were made, using a L & N Quinhydrone pH Indicator with a saturated Calomel electrode. The technique followed was similar to that which Brown and Price (5) found to be satisfactory.

N-Butyl Alcohol Extraction of Ripened Cheese

A modification of Dakin's (6) method of n-butyl alcohol extraction of hydrolyzed protein was made to secure mono-amino acids from ripened cheese. The cheese samples after being grated to shreds were extracted with petroleum ether until practically fat free. Two hundred to five hundred grams of cheese were extracted four times with one liter of hydrated n-butyl alcohol. The cheese and butyl alcohol were mixed by shaking on a mechanical shaker one to two hours for each extraction. The alcohol extract was filtered and then evaporated under reduced pressure at 30° C. to about one-fourth its volume. By that time the mono-amino acids had crystallized in the dry butyl alcohol so that they could be filtered off, dried, weighed, and analyzed by x-ray diffraction methods.

Manufacturing Procedure for Cheese Used for Chemical and X-ray Analysis

The manufacturing procedure for the two lots of cheddar cheese used in the ripening study was varied in such a way as to produce one lot which would cure slowly and the other lot which would ripen rapidly. This was done by varying the amount and rate of acid development. Lot 1115 was the slow ripening cheese and lot 1120 was the rapid curing cheese. Both lots were made from pasteurized milk of low bacterial count. The manufacturing data for the cheese is listed in Table 1.

During the manufacturing process samples of the cheese were taken for x-ray analysis. Also at definite intervals throughout the ripening period, the cheese was subjected to x-ray examination and chemical analysis in order to correlate the changes in the patterns that occurred with the rate

TABLE 1

Manufacturing data for experimental cheese

	Lot 1115	Lot 1120
Pounds of milk	891	339
Weight of cheese made	91.25	35.5
Per cent of starter used	1.5	2.25
Incubation time at 86° F.	90 min.	150 min.
Titratable acidity of whey at curd cutting	.09%	.145%
pH of whey at cutting	6.74	6.32
pH of curd at cutting	6.75	6.28
Titratable acidity of whey at dipping	.12%	.29%
pH of whey at dipping	6.41	6.01
pH of curd at dipping	6.38	5.54
Titratable acidity of whey at milling	.45%	.8%
pH of whey at milling	5.57	5.13
pH of curd at milling	5.57	5.23
pH of curd at dressing	5.57	5.23
pH of curd after 24 hours	5.24	5.04
Per cent of water in freshly made cheese	36.9	35.5

of protein hydrolysis. Ripening of the cheese was carried on in a cold storage room, the temperature of which was controlled at 10° C. ± 1.5° C.

DISCUSSION OF EXPERIMENTAL RESULTS

Chemical Analysis

Since the data obtained by chemical analysis is comparable to the work of previous investigators, a discussion of these results will be omitted.

Analysis of Cheese by X-Ray Diffraction Methods

The manner in which x-rays have been used in this part of the study is comparable to qualitative in contrast to quantitative analysis. A series of standard x-ray diffraction patterns of the amino acids which occur in casein were made and the spacings calculated. The calculated spacings of the cheese patterns and the spacings of the mono-amino acid extract from the cheese were then correlated with the spacing values of the standard patterns of the amino acids.

As has been shown in the previous paper the diffraction pattern of casein upon x-ray analysis shows two halos at calculated spacings of 4.6 Å and 9.8 Å, which are similar to other proteins as found by Astbury (7) and others (8). The outer halo at 4.6 Å represents the perpendicular distance between the layers of polypeptide chains. Astbury has called this the "backbone" spacing. The inner halo at approximately 9.8 Å represents the length of the polypeptide side chains.

Theoretically, in terms of the dimensions of the CH_2 and CONH groups, the packing of peptide chains in the two planes should be given by 4.64 Å

and 9.68 Å, provided the amino acids of the chain are on the average of the length of valine (9). The casein values as determined, therefore, agree well with the theoretical prediction.

In order to secure the desired information about cheese ripening, diffraction patterns of the two lots, 1115 and 1120, were secured at regular intervals. Coagulation of casein by rennin and the formation of paracasein are fundamental to the process of making cheese. Accompanying this coagulation reaction marked changes occur not only in the chemical properties of the casein but in the physical as well. It becomes elastic and while warm will stretch into long strings, which shatter and break readily on cooling. However, the same x-ray diffraction patterns were obtained for casein, paracasein, and stretched paracasein. Proteins, such as keratin, and gelatin, when stretched show a marked change in structure, with a decided orientation of diffracting groups. Apparently stretching of paracasein is not a true stretching comparable to that which occurs when tension is placed on rubber or muscle fiber, but is more similar to a plastic flow.

Although the patterns of fresh cheese or paracasein are the same as the patterns for any type of casein, the x-ray pattern changes quite rapidly under certain conditions as the cheese ripens. The changes that occur may be briefly described as follows:

First, the outer halo gives way to two sharply defined rings at the inside and outside of the halo. The spacings are at approximately 4.6 Å and

TABLE 2

Calculated values for the spacings determined from the diffraction patterns, cheese 1115

Sample treatment				Ave. value for "d" spacings during period	Ave. "d" spacings for 30 other samples
1115 plain	1115 plain	1115 plain before H_2O extract	1115 after H_2O extract		
Date of exposure					
11–16–35	11–20–35	5–31–36	5–31–36		
Age of cheese in days					
1	5	196	196		
9.7	9.78	9.53	9.90	9.80	9.73
	7.58	7.60	7.61	7.62	7.55
4.6	4.55	4.55	4.57	4.58	4.60
	4.14	4.19	4.23	4.22	4.23
		3.82	3.8	3.82	3.83
					3.40
	3.01 S*	3.07 S	3.03 S	3.04	3.05
	2.89 S	2.92 S	2.91 S	2.91	2.92
	2.57 S	2.64 S	2.60 S	2.60	2.61
				2.42	2.43

* S = Strong intensity.

4.23 Å. The inner halo is retained, but a new spacing appears at 7.6 Å near the outer edge of this small inner halo. The above changes are the first to appear in the ripening process. As the period progresses other spacings are brought out in the x-ray diffraction pattern. These spacings have been calculated to be at 3.85 Å, 3.42 Å, 3.08 Å, 2.92 Å, 2.61 Å and 2.43 Å. The typical patterns of unaged and aged cheeses are illustrated by Figures 1 and 2. Figure 3 shows two patterns on the same film and illustrates clearly the sharp contrast between the diffraction rings of the unaged and the aged cheese samples.

In Tables 2 and 3 are listed the calculated values for the spacings determined from the diffraction patterns which were made throughout the ripening period of the cheese samples.

The most variable spacing in the cheese is the one which represents the length of the peptide side chain linkage. This spacing, in lot 1115, varied from 9.4 Å up to 10.1 Å. However, this value is more constant between the 1115 samples and the total variation is not as great in this lot as in lot 1120. For in this group of samples, the spacing values varied from 9.12 Å to 10.5 Å. Clark and Schaad (10) consider that the different values found for this spacing in other proteins are due to the difference in the amount of water retained by the protein. It is true that when a sample of moist cheese is ex-

TABLE 3

Calculated values for the spacings determined from the diffraction patterns, cheese 1120

Sample treatment				Ave. value for "d" spacings during period	Ave. "d" spacings for 30 other samples
1120 Plain	1120 Plain	1120 before H_2O extract	1120 after H_2O extract		
Date of exposure					
11–21–35	11–26–35	5–20–36	5–20–36		
Age of cheese in days					
1	6	181	181		
9.5	9.12	9.95	9.9	9.8	9.73
	7.68	7.65	7.65	7.66	7.55
4.61	4.65	4.7	4.62	4.63	4.60
4.3 V.F.*	4.2	4.3	4.29	4.28	4.23
			3.86	3.83	3.83
					3.40
	3.03 V.F.	3.07 S	3.07 S	3.04	3.05
	2.89 V.F.	2.94 S	2.94 S	2.90	2.92
	2.60 V.F.			2.60	2.61
					2.43

* V.F. = Very faint intensity.
S. = Strong intensity.

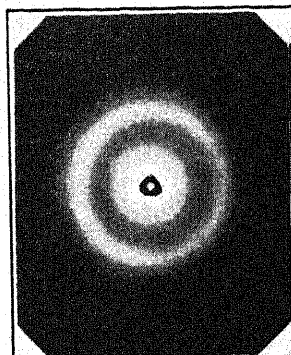
Fig. 1

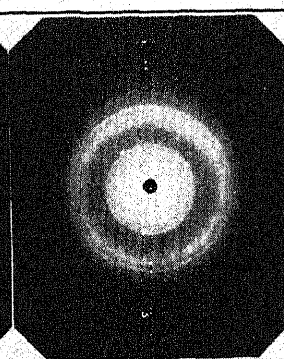
Fig. 2

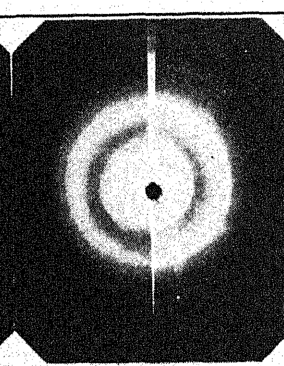
Fig. 3

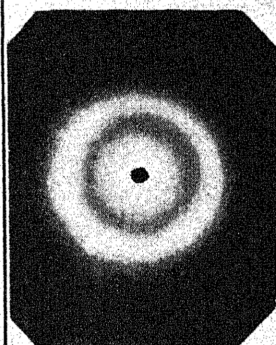
Fig. 4


Fig. 5

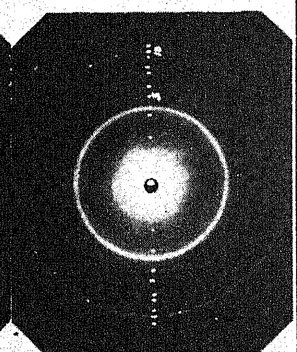
Fig. 6

Fig. 1 Fresh Cheese

Fig. 2 Aged Cheese

Fig. 3 Fresh and Aged Cheese

Fig. 4 Cheese Showing Isoleucine

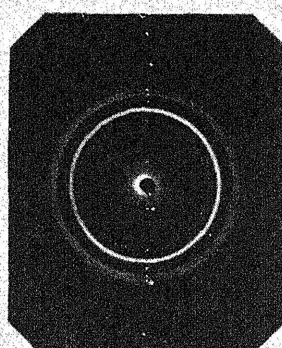
Fig. 7

Fig. 5 Same Cheese after Extraction with n-butyl Alcohol

Fig. 6 Amino Acid Extract from Aged Cheese

Fig. 7 Amino Acid Extract from 1 day old Cheese

amined by x-rays this halo becomes indistinct and decreases in diameter, a change which indicates a larger "d" spacing.

The values for the other spacings do not exhibit the variability of the first spacing, but are surprisingly uniform. The interesting observations about the remaining spacings are the time of occurrence and the intensity of diffraction lines. The question arises as to the significance of these new spacing values in the cheese paracasein. Three possibilities might be advanced to

explain their presence. First, since cheese ripening represents an hydrolysis of protein and a liberation of amino acids, the diffraction lines may be due to amino acids. Second, the mineral constituents of the cheese may have crystallized and the characteristic pattern may be the result of the diffraction of the x-rays by the mineral salts. Third, the minerals or the amino acids may be combined with the paracasein in such a manner as to produce a crystalline pattern but still not exist as pure crystalline substances in the cheese.

If the characteristic pattern of cheese paracasein were due to free amino acids, then this pattern should be changed by the extraction of the cheese in water or hydrated n-butyl alcohol. The alcohol is a solvent for the mono-amino acids and the di-amino acids are also slightly soluble in and extracted by the n-butyl alcohol. However, the spacing values of the cheese protein are not changed by extraction of the cheese in either this solvent or water. Diffraction patterns were made of di-calcium phosphate, tri-calcium phosphate, calcium lactate and mixtures of these, but the spacing values of the cheese could not be reproduced.

On the other hand when the cheese was extracted in 10 per cent HCl, which is a solvent for both minerals and amino acids, the characteristic pattern of the cheese disappeared and the pattern reverted to one of two halos characteristic of the plain protein at the beginning of the ripening period.

In Table 4 are listed the amino acids that could possibly account for the spacing values. However, because of the similarity in structure of the amino acids the "d" spacings are approximately the same. Hence, the amino acids could not be identified specifically by these values although some weight might be attached to the fact that the spacings for isoleucine, leucine, valine, OH-proline, proline, aspartic acid and tyrosine occur most often.

Extraction of Cheese with Hydrated n-Butyl Alcohol

Dakin (6) proposed a method for the separation of amino acids into groups after the protein had been hydrolyzed by sulphuric acid. He considered that the mono-amino acids were soluble in n-butyl alcohol and could, therefore, be separated from the di-amino and di-carboxylic acids, which were supposedly insoluble in that reagent. Later investigators, notably Rose and his students, have shown that the alcohol extract does contain considerable amounts of the di-amino acids as well as proline and hydroxy prolines. However, Rose and his associates (11) were led to their discovery of the new essential amino acid, threonine, through the use of the butyl alcohol extraction method in isolating amino acids for feeding experiments.

The separation of amino acids from their mixtures is decidedly difficult because of the similarity of properties of the various amino acids. It was decided, therefore, to determine the adaptability of x-ray analysis to the identification of amino acids in the mixtures that would likely occur in the alcohol extract from the cheese.

TABLE 4

"d" spacings in Å found in cheese	"d" spacings in Å in amino acids
7.62—(1115) 7.66—(1120)	7.61 Histidine—HCl
4.58—(1115) 4.63—(1120)	4.64 Methionine 4.60 Arginine 4.56 Valine 4.54 Isoleucine
4.22—(1115) 4.28—(1120)	4.22 Leucine 4.23 Aspartic acid 4.26 Hydroxyproline 4.27 Phenylalanine
3.82—(1115) 3.82—(1120)	3.80 Histidine 3.84 Isoleucine 3.84 Phenylalanine 3.86 Aspartic acid 3.87 Proline 3.87 Alanine
3.42	3.4 Valine 3.4 Tyrosine 3.4 Proline 3.4 Threonine 3.45 Alanine
3.04—(1115) 3.04—(1120)	3.08 Glutamic acid 3.08 Phenylalanine 3.09 Histidine—HCl
2.91—(1115) 2.90—(1120)	2.90 Isoleucine 2.93 Tyrosine 2.95 Leucine 3.00 Valine
2.60—(1115) 2.60—(1120)	2.61 Isoleucine 2.61 OH—proline 2.62 Proline 2.62 Norleucine 2.63 Valine 2.63 Arginine 2.64 Tyrosine
2.43—(1115)	2.40 Leucine 2.41 Isoleucine 2.41 Methionine 2.41 Histidine—HCl 2.41 Threonine 2.46 Valine

Standard patterns of the amino acids occurring in casein were made, as well as patterns of physical mixtures of some of them. The spacing values for the various mixtures are illustrated in Table 5. As can be seen, when there is a mixture in equal amounts of only two amino acids (namely, leucine and isoleucine), it is relatively simple to identify them. However, when tryptophane is added to the mixture another problem arises, that of destructive interferences. There is one spacing value, 17.1 Å, that is specific for

TABLE 5

Standard spacing values for isoleucine and leucine (1 to 1) mixture			Standard spacing values for leucine, isoleucine, and tryptophane (1 to 1 to 1)		
Spacing on pattern of mixture in Å	Standard pattern value in Å		Spacing on pattern of mixture in Å	Standard pattern value in Å	
13.03	Isoleucine	13.03	17.1	Tryptophane	17.1
6.4	Isoleucine	6.52	13.02	Isoleucine	13.03
5.51	Isoleucine	5.51	6.5	Isoleucine	6.52
4.96	Leucine and				
	Isoleucine	4.98	5.55	Isoleucine	5.51
			5.02	Leucine and	
4.65	Leucine	4.65		Isoleucine	4.98
4.18	Isoleucine	4.18	4.68	Leucine	4.65
4.01	Leucine and	4.00			
	Isoleucine	4.02	4.24	Leucine	4.22
			4.08	Leucine	4.00
3.84	Isoleucine	3.84		Isoleucine	4.02
3.47	Leucine	3.48	3.88	Isoleucine	3.88
			3.52	Leucine	3.48
3.24	Isoleucine	3.24		Isoleucine	3.50
3.16	Leucine	3.17	3.22	Isoleucine	3.24
2.95	Leucine	2.95	3.02	Isoleucine	3.00
			2.92	Leucine	2.95
2.89	Isoleucine	2.89		Isoleucine	2.89
			2.79	Leucine	2.77
2.77	Leucine	2.77		Isoleucine	2.76
2.67	Isoleucine	2.67	2.62	Isoleucine	2.60
2.60	Isoleucine	2.60	2.52	Isoleucine	2.51
			2.42	Isoleucine	2.41
2.50	Isoleucine	2.51		Tryptophane	2.45
2.40	Leucine	2.41			

tryptophane and if this spacing had not appeared, tryptophane could not have been identified as being part of the mixture. This indicates that qualitative chemical tests should also be made on mixtures so as to serve as confirmatory tests. The observation that the spacings for tryptophane were absent is significant because it held true in the unknown cheese extracts, when even one characteristic spacing value for tryptophane did not appear. However, the Hopkin's Cole test showed tryptophane to be present in all the extracts except the one from cheese one day old.

In the first part of Table 6 there is listed the values for the spacings as found in the extracted material from a cheese one day old. The spacing values are, without much doubt, due entirely to leucine and isoleucine. Apparently then, these two amino acids are liberated fairly rapidly in the hydrolysis of casein during cheese ripening. There was a negative test for tyrosine, although one would expect tyrosine to be liberated just as early as leucine and isoleucine. Evidently this was not the case. In fact, in testing all of the cheese extract samples, a much stronger test was obtained for tryptophane than for tyrosine, providing tryptophane was present at all. Womack and Rose (12) have found that leucine and isoleucine crystallize at

TABLE 6

Identification of amino acids in butyl alcohol extract from cheese

First extraction from cheese 426 age, 1 day			First extraction from cheese 2235 age, 4 months		
Value for mixture	Standard pattern value		Value for mixture	Standard pattern value	
13.9	Leucine	14.2	13.95	Leucine	14.2
			9.35	Lysine	9.05
5.25	Leucine	5.24	6.45	Tyrosine	6.55
				Isoleucine	6.53
4.55	Isoleucine	4.54			
	OH—Proline	4.52	4.75	Phenylalanine	4.75
				Leucine	4.72
				OH—Proline	4.72
			3.93	Tryptophane	3.95
4.16	Isoleucine	4.15		Leucine	4.00
			3.34	Phenylalanine	3.32
				Methionine	3.36
3.86	Isoleucine	3.84	3.23	Isoleucine	3.24
	Phenylalanine	3.84		Methionine	3.23
				Proline	3.21
3.69	Isoleucine	3.68		OH—Proline	3.22
	Histidine	3.68			
			3.10	Phenylalanine	3.08
				Histidine—HCl	3.09
2.55	Leucine	2.55		Arginine	3.10
			2.91	Isoleucine	2.91
				Tyrosine	2.93
2.34	Leucine	2.30	2.47	Isoleucine	2.41
				Methionine	2.41
				Histidine—HCl	2.41
Negative—Hopkins Cole Negative—Millon test for Tyrosine Negative—unoxidized sulphur test			Positive—Hopkins Cole for Tryptophane Sl. positive for Tyrosine by Millon's reagent Negative for unoxidized sulphur		

the same time when in a mixture. X-ray analysis can detect the presence of either of these when they exist in appreciable amounts in a mixture, as is shown by Table 5.

Figures 4 and 5 illustrate that leucine can be extracted from an aged cheese sample. The small inner ring on the cheese pattern of Figure 4 indicates a spacing which is specific for leucine. Upon extraction of the cheese by n-butyl alcohol, this ring disappeared. (See Figure 5.) However, the x-ray diffraction pattern of the amino acid extract shows that it is present there. (Figure 6.)

In part two of Table 6 are shown the spacing values for a cheese sample four months old. Lysine might be present, in addition to leucine, isoleucine, tryptophane, and tyrosine.

Table 7 lists the values for the extract from a cheese sample approximately eighteen months old. The presence of leucine and isoleucine are clearly illustrated. Tyrosine and tryptophane were shown to be present by the characteristic color tests for amino acids that were applied to the crystalline material.

TABLE 7

Identification of amino acids in butyl alcohol extract from cheese

First extraction from cheese 12274 age, 15 months			First extraction from commercial cheese age, approximately 18 months		
Value for mixture	Standard pattern value		Value for mixture	Standard pattern value	
13.9	Leucine	14.2	14.3	Leucine	14.2
7.31	Aspartic acid	7.42	7.31	Aspartic acid	7.42
5.21	Leucine	5.24	4.99	Isoleucine	4.99
				Leucine	4.98
4.60	Isoleucine	4.56		Tyrosine	4.90
	Arginine	4.60			
			4.56	Isoleucine	4.54
4.00	Leucine	4.00		Proline	4.53
	Isoleucine	4.02		OH—Proline	4.52
	Phenylalanine	3.99			
			4.07	Aspartic acid	4.06
3.65	Isoleucine	3.68		Isoleucine	4.03
	Serine	3.66		Tyrosine	4.09
	Phenylalanine	3.64		Threonine	4.09
	OH—Proline	3.64			
			3.58	Tyrosine	3.59
3.25	Isoleucine	3.24			
	Proline	3.21	3.23	Isoleucine	3.24
	OH—Proline	3.22		OH—Proline	3.22
				Methionine	3.22
2.97	Leucine	2.96			
	Arginine	2.97	3.12	Leucine	3.15
	Lysine	2.95		Aspartic acid	3.13
				Lysine	3.13
2.82	Leucine	2.82			
	Threonine	2.82	2.80	Leucine	2.82
				Proline	2.80
2.40	Leucine	2.40			
	Isoleucine	2.41			
	Arginine	2.40			
	Threonine	2.40			
Positive—Hopkins Cole test			Positive—Hopkins Cole test		
Sl. positive—Millon's test			Positive—Millon's test		

Figures 6 and 7 show the x-ray diffraction patterns of the amino acid extracts from two different samples of cheese. As one can observe, there is a difference in the patterns, indicating that the crystalline extracts were not identical in composition in all respects. The calculations of the spacing values listed in the Tables 6 and 7 also show that this is true.

A Long Interplanar Spacing in Cheese

Clark and Schaad (10) have shown that certain proteins; namely, nerve tissue and intestinal wall collagen, contain certain long spacings that can be isolated by a special technique. Spacings varying from 70 Å up to 400 Å have been found in intestinal wall collagen when using a vacuum camera and a distance of 20 cm. from specimen to film. The long spacing which was found in cheese, but which was absent from casein, was calculated to be

39.7 Å. However, the nonappearance of the long spacing interference in pure casein is still unaccounted for.

Svedberg (13) calculated the radius of the casein particle, assuming that it was spherical, to be 41.7 Å to 59.94 Å. The two values, 41.7 Å for casein and 39.7 Å for cheese, are of the same order of magnitude. Therefore, it is possible that this spacing represents the radius of the casein particle, or the maximum length of the side chain spacing from the main chain. If this be true, the size of the casein particle which has been arrived at by another method agrees well with that determined by Svedberg.

SUMMARY

An attempt has been made to follow the changes which occur during the ripening of cheddar cheese by x-ray diffraction analysis.

The diffraction pattern of the cheese protein after aging is markedly different from the pattern of the fresh cheese. The pattern appears to be due to crystalline material, although the identification of the material has not been made as yet.

Standard patterns were made and "d" spacing values were calculated for the amino acids occurring in casein in order to determine whether the characteristic pattern was due to an amino acid of low solubility.

By the extraction of the aged cheese in hydrated n-butyl alcohol, amino acids were extracted from the cheese and identified. Leucine and isoleucine were obtained from cheese 24 hours after being made. Tyrosine, and probably tryptophane were also identified in the extract obtained from ripened cheese. A long interplanar spacing of 39.7 Å was obtained from cheese protein. This spacing represents the length of a side chain from the main chain and corresponds closely with the radius of the casein particle which Svedberg determined to be 41.7 Å to 59.9 Å

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JUDGING SWEET CREAM

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The more general application of scientific methods in the production, manufacture and merchandising of dairy products during the last quarter century has very markedly improved the quality of the goods which the industry offers to the consumer. Whether one contemplates large scale production such as is realized in the thrice-daily milking of 1600 cows on one large eastern farm, or a city pasteurizing plant processing 400,000 pounds or more of milk daily, or the nation-wide marketing methods of the larger dairy manufacturers, one is everywhere impressed by the emphasis laid on the fine, healthful quality of the product. This growing stress on quality is making the consumer more discriminating in the selection of brands or sources of supply and would seem to require that the industry reexamine carefully the methods of measuring quality which are currently employed for this purpose.

In the past little attention has been given to the evaluation of the quality of sweet fluid cream offered to the public for use in coffee, with fruits and cereals, or as a whipped cream. It is true that the U. S. Department of Agriculture some years ago adopted, with the approval of the American Dairy Science Association, a score card for the alternative judging of milk or cream. (1) This score card allotted 40 points to physical characteristics, divided into 25 points for flavor, 10 for sediment and 5 for package, and 60 points to laboratory-tested qualities, of which 45 depended on total plate counts of microorganisms and 15 on titratable acidity or, alternatively, the temperature of "street" samples.

Regardless of opinion as to whether such a weighting of the several factors is justifiable or desirable in judging fluid milk as marketed today, there can be little doubt that sweet fluid cream should be rated on a different basis. In the first place, the volume of milk now being sold in the form of sweet cream is sufficient to warrant separate consideration for this product, and, in the second place, the qualities which determine the marketability of cream differ considerably from those which determine the marketability of milk.

Statistics compiled by the Federal government in several of the large eastern markets (2) show that at least 40 per cent of the total fluid milk volume consumed in these markets is distributed in the form of fluid cream. This relationship may not hold exactly in all sections of the United States, but is probably applicable to most urban centers where the bulk of sweet cream sales occurs.

Received for publication June 1, 1938.
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It is evident that sweet cream occupies, both from the dollar value and from the volume of milk required for its manufacture a very high place in the economics of fluid milk distribution.

The question arises as to what characterizes high quality in fluid cream. Certainly flavor is of prime importance, since a large proportion of the fluid cream sold is consumed on fruits, cereals, cake, etc., which do not mask the flavor of the cream itself. Off-flavors in cream are a primary source of customer complaints. For this reason the distributor of fluid cream is very conscious of the necessity of excellence of flavor. It would seem reasonable in scoring cream that flavor should be given as much consideration as in scoring butter, where forty-five points out of 100 are allotted to flavor.

"Pourability" or consistency, or viscosity, is another factor of prime importance in the eyes of the customer. Being aware of the general association of increased body with higher fat content, the housewife suspects a thin-pouring cream as being low in butterfat and is likely to enter a complaint with her distributor.

Whipping quality is probably more troublesome today to the milk distributor than any other characteristic of fluid cream. Many resort to the costly expedient of increasing the fat content to satisfy their customers as to whipping quality. Others add "viscogen," lecithin or skim milk solids, practices which are illegal in many areas and which are eschewed by leaders in the industry as partaking of adulteration.

Cream "plug," giving rise to oiliness in coffee, is a frequent defect of fluid cream, while the separation of a serum layer in bottled cream is a very common occurrence in the lower fat ranges. Sediment, showing lack of cleanliness in production and handling, must always be considered in judging quality. The appearance of the container is a factor which is being emphasized in all food merchandising today and should be accorded some weight in any rating of quality of a packaged food.

The present score card for milk and cream allots 45 points to total bacterial counts, giving a cream with a plate count of 100,000 organisms per ml. a zero score in this bracket. This emphasis on bacterial content seems entirely out of proportion to its importance today. Under modern conditions of city milk regulation and inspection the general condition of fluid cream from a bacteriological standpoint is quite satisfactory. The public is adequately protected from pathogenic organisms by pasteurization requirements, and the subsequent protection of the product against temperature change, so that total counts are of importance mainly because of the effect of putrefactive and acid types of organisms on flavor and keeping quality. If samples are judged twenty-four hours after processing, the effect of objectionable high counts will probably be manifested in off-flavors. For these reasons we believe that 15 points gives sufficient weight to bac-

terial counts, penalizing a sample one point for each 10,000 per ml. count above 10,000. By this means any cream containing in excess of 160,000 bacteria per ml. would be penalized 15 points.

Acidity is of importance as it affects keeping quality and flavor. Prevailing conditions of producing and processing sweet cream result in low acidities as well as low bacterial counts at time of packaging. Since subsequent carelessness in handling may lead to bacterial growth and developed acidity, a small penalty for acidity increase would appear to serve for

TABLE I

Cream Score Card

Sample No. ——————— Butterfat Content ——————— Date ———————

Judge after 24 hrs. aging Enter observed data—Underline defects	Perfect score	Points deduct.	Score allow.
FLAVOR: Exc. (34–40) No definite criticism	40	———	
Good (28–33) Very slight feed, sl. cooked		———	
Fair (23–27) Cooked, feed, sl. unclean or metall.		———	
Poor (13–22) Metallic, str. feed, unclean, sl. acid, sl. rancid or tallowy		———	
Bad (0–12) Sour, foreign, racid, tallowy, putrid		———	———
BODY: *Light Cream Score* *WHIPPING*	20		
———sec. Exc. (92 to 100%) 18–20 Sec. to whip ———			
———sec. Fair (72–92%) 13–17 4 points for Exc.			
———sec. Poor (48 to 72%) 7–12 Cm. Penetr. ———	Body	———	
Heavy Cream Score 2 points for Exc.			
———sec. Exc. (as above) 9–10 Volume Incr. ———%			
———sec. Fair (" ") 6– 8 2 points for Exc.			
———sec. Poor (" ") 2– 5 Ml. Leakage ———	Whip.	———	
Refer to tables for Excellent standards 2 points for Exc.	Total	(20 max)	———
N.B. If whipping tests not made, score *Heavy Cream* Body same scale as light.			
BACTERIA COUNT: 10,000 or less considered perfect. For higher counts deduct 1 point per 10,000 additional	15		
———per ml.		———	———
CREAM PLUG: Deduct: 0–1 Sl., soft, foamy plug	5		
1–2 Distinct soft plug			
2–3 Buttery plug			
4–5 Leathery plug		———	———
SERUM SEPARATION: Deduct 1 point for each 1/16″ serum	5	———	———
ACIDITY: Deduct 1.0 for each 0.1% acid above normal acidity for cream of specified fat content	5	———	———
SEDIMENT: Penalize in proportion to specks or dirt	5	———	———
PACKAGE: Dirty bottle—deduct 0.5–1.0	5		
Bottle etched or chipped—deduct 0.25–1.0			
Slack fill—deduct 1.0 for each ¼″ short			
Unprotected lip—deduct up to 1.0 point			
Poor cap condition—deduct up to 1.0		———	———

COMMENTS: TOTAL SCORE———————

Scorer ———————

quality maintenance. Actual souring would be severely injurious to good flavor and would bring a correspondingly heavy penalty in that part of the score.

With these ideas in mind it appeared desirable to propose a new method for the evaluation of the quality of fluid cream, one which would reflect more accurately the various factors entering into its determination and one which might be better adapted to conditions in the industry today. We believe that this subject merits thoughtful consideration by dairy science workers, both in the academic and in the industrial fields. In the following scheme (Table I) which has had a year's practical trial in a number of fluid milk plants with favorable endorsement, 40 points are allotted to flavor, 20 points to body or body and whipping quality, 15 points to bacterial counts, 5 points each to "plug," serum separation, acidity, sediment and package.

COMMENTS ON SCORE CARD

Quart samples of cream are required to complete all determinations required by the score card. All measurements should be made on creams 24 hours after bottling.

The off-flavors referred to are so well-recognized and defined as to require no elaboration here. Any particular criticisms may be indicated by underlining the appropriate terms. Body and whipping quality present more of a problem in evaluation. Twenty points are suggested for this group, all of which are allotted to body for creams of lower fat content, but are divided between the two for those classified as "whipping creams." Hening (3) has discussed the measurement of the viscosity of cream by means of the MacMichael viscometer and the Borden Flow Meter. It is proposed to use these instruments alternatively, scoring this quality according to the reading obtained. In Table II there is suggested a range of

TABLE II

Viscosity of fluid cream at 15.5° C. (60° F.)

% B.F.	Body flow time (seconds)		Viscosity (centipoises)		% B.F.	Body flow time (seconds)		Viscosity (centipoises)	
	Exc.	Poor	Exc.	Poor		Exc.	Poor	Exc.	Poor
18	38 –	26	2 –	1.75	32	75 –	42	18 –	6
20	40 –	28	7 –	2.0	34	90 –	48	22 –	12
22	44 –	30	8 –	2.25	36	120 –	60	29 –	14
24	48 –	32	11 –	2.5	38	170 –	85	38 –	22
26	52 –	34	12 –	2.5	40	230 –	115	47 –	25
28	58 –	36	14 –	3.	42	290 –	145	60 –	34
30	65 –	38	15 –	4.	44	360 –	180	65 –	39

expected values which experience indicates to be reasonable for pasteurized cream aged 24 hours in the original package.

The numerical score to be assigned to a cream of a given fat content is determined by the percentage of the "Excellent" value obtained for the particular sample, as indicated in the score card.

WHIPPING QUALITY

If whipping creams are to be rated for whipping quality, it is essential to employ a standard method which is simple, easily reproducible and employs inexpensive equipment. Several procedures have been described by investigators (4, 5, 6, 7, 8, 9, 10). It is believed the following one well meets the requirements laid down:

Equipment

1. "Duplex" whipper and bowl.*
2. 250 and 100 ml. graduates.
3. 600 ml. beakers.
4. 40 gm. Penetrometer (see Figure 1).
5. 90 mm. 60° glass funnels.
6. 1″ wire screen discs (20 mesh per inch)
7. Thermometer, grease pencil, spatula, stop watch.

Method

While the score card should normally be applied to samples 24 hours after pasteurization, it may happen that the bottle of cream has warmed up somewhat before examination. For this reason it is desirable to make certain that the sample has been held below 7° C. (44.6° F.) for at least two hours prior to testing. Cool whipper and bowl to same temperature before making test.

1. Measure 200 ml. of cream into bowl. Adjust temperature to 7° C. With uniform speed of whipper (120 R. P. M.), record *whipping time* in seconds to whip cream to maximum stiffness. Avoid over-whipping.

2. Transfer whipped cream to a 600 ml. beaker, gently tap bottom of beaker on palm of hand to pack and level the whipped cream, mark the surface level with grease pencil for making *volume determinations* later.

3. Determine *stiffness of whip* with penetrometer. Tighten glass sleeve of instrument in burette clamp at a convenient height. Raise penetrometer with fingers so beaker may be set beneath it. Lower the stem until disc just rests on surface of the whipped cream. Release fingers after noting reading on stem opposite upper edge of sleeve. Record penetration in cms./min.

4. Transfer whipped cream to glass funnel fitted with wire disc as a support for cream. Place graduated cylinder under funnel to collect leakage. Expose samples for 2 hours at room temperature (20–22° C.) Record *leakage* in milliliters for 2 hour period.

5. After removing whipped cream from beaker, fill to whipped cream level with water and measure for *volume*. Record the percentage increase in volume.

* Manufactured by V. V. Vale Corporation, Oak Park, Illinois.

Ten points are allotted to whipping quality, divided between stiffness, volume increase, leakage and time to whip. In Table III is suggested a tentative criterion for evaluation of these factors.

TABLE III

Whipping quality of cream

	Excellent	Fair	Poor
Time to whip	Under 40 seconds	40–90 seconds	Over 90 secs.
Stiffness	No penetration	0–2.0 cm./min.	Instant penetration
Volume increase	90–110%	70–90%	70% or less
Leakage	< 4 ml.	4–14 ml.	14–20 ml.

Blank spaces are provided on the score card for recording the actual measurements in determining body and whipping quality.

BACTERIA COUNT

Total plate counts are determined by the A. P. H. A. standard method for milk. If less than 10,000 per ml. the sample receives a full score of 15. One point is deducted for each ten thousand or fraction thereof above ten thousand per ml.

SERUM AND PLUG

Serum separation is easily recognized by the distinct bluish layer in the bottom of the bottle, which frequently occurs following storage. "Plug" is best observed through removal of the bottle cap. It is objectionable to the consumer because it hinders pouring and causes oiliness on the surface of hot coffee. The deductions proposed in the score card are self-explanatory.

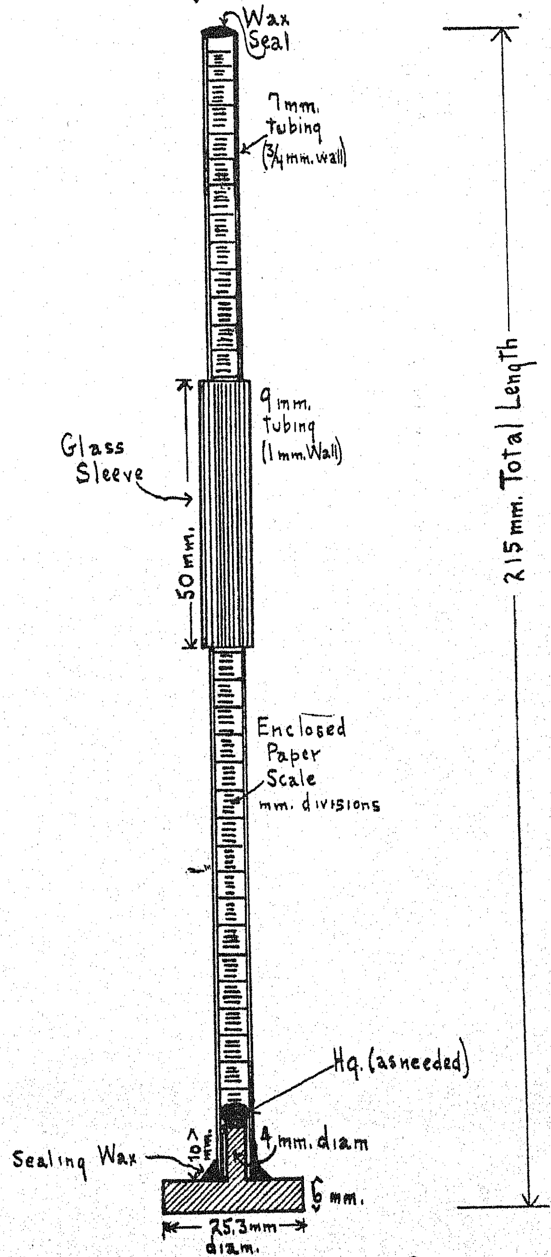
ACIDITY

The acidity should be determined by titration of a 9 cc. portion of the cream diluted with 9 cc. of distilled water, using N/10 alkali and 3 drops of phenolphthalein indicator. Since the acidity of cream depends upon the serum present, it will vary inversely with the fat content of the cream. Hence, limits for permissible acidity are determined by calculating the observed titratable acidity value to the basis of the serum alone. A reading of 0.11 per cent in 40 per cent cream is equivalent to 0.18 per cent in skim milk and represents the maximum permissible for a perfect score. One of over 0.14 per cent in 40 per cent cream, equivalent to 0.23 per cent in the serum portion, would be scored zero. Corresponding limits for 20 per cent fat cream would be 0.145 per cent and 0.185 per cent acidity. For intermediate fat contents similarly calculated limits should be used.

SEDIMENT AND PACKAGE

Deductions for sediment are based upon the appearance of filter discs obtained by filtering pint samples of cream. A method for preparing such

Fig. 1



Penetrometer for Whipped Cream

discs has been proposed (11) which consists of diluting one pint of cream with an equal volume of filtered hot water, and filtering it through one of the standard milk sediment testers at a temperature of about 50° C. Deductions for sediment are made in proportion to the dirt on the disc.

The defects in package are the same as those now recognized in scoring milk and cream.

PLANT APPLICATION

The proposed method for determining the quality of sweet cream has received practical trial in the laboratories of a number of plants. Some have used the score card as a daily routine procedure, particularly for light cream. Others have employed it in periodical surveys of samples distributed in given local areas. The results of the examination of several hundred creams of different fat contents have been recorded. The scores ranged from a maximum of 98 to a minimum of 48, indicating the potential value of such a numerical expression of measurable characteristics as a yardstick by which high quality can be maintained in day-to-day production. Comments made by individual workers indicate their appreciation of the value of such a written record. The score card in its present form appears to offer a convenient, workable tool for routine laboratory control purposes as well as an excellent technique for comparing the quality of a group of cream samples as to their consumer appeal.

CONCLUSIONS

It is the belief of the authors that present-day quality in sweet cream as distributed in urban centers merits careful consideration of a number of characteristics not recognized in the score card now used interchangeably for milk and cream. At the same time, modern practice makes a different weighting of individual qualities appear desirable. A separate score card for cream is suggested, with proposed methods for judging the respective characteristics, and details of application are given. The suggested scheme has received practical trial in a number of commercial control laboratories, where it has proven workable and convenient, reflecting in an exact manner the differences which are distinguishable in a general way between samples of cream. The official adoption of such a score card, or some suitable modification of the same, would provide both the academic and the industrial investigator with a recognized standard method for evaluating cream quality as it is offered to the public under modern marketing conditions.

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FACTORS AFFECTING THE ACTIVITY AND HEAT RESISTANCE OF SWISS CHEESE STARTER CULTURES. I. INFLUENCE OF TIME AND TEMPERATURE OF INCUBATION[1]

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Frazier and coworkers (7), in their studies on the bacteriology of Swiss cheese, found that cultures of *Lactobacillus helveticus* 39a, incubated at 38° to 39° C., developed more actively during the manufacture of Swiss cheese than did those incubated at 35° to 37.5° C. Unpublished results indicated that when *L. helveticus* had been grown in milk at 30° C. for 24 hours, it showed definitely less activity in the cheese on the press than when it had been grown at 37° C. for 12 hours. Despite the fact that cultures grown at the two temperatures produced about the same amount of titratable acid at the end of their respective incubation periods and presumably were of approximately the same maturity, the culture grown at the higher temperature had the greater ability to withstand heating.

During the manufacture of Swiss cheese, the temperature of the curd is raised in a period of about 30 minutes from the average setting temperature of 33° C. to an average cooking temperature of 53° C. The curd is held at or slightly below this temperature for about 30 minutes, after which it is removed from the kettle and placed in the press. The temperature falls very slowly during the next 24 hours, particularly in the center of the cheese. It is obvious then than any organisms which develop in the early hours on the press must be both heat resistant and capable of developing readily at temperatures near their maximum.

A study was made to determine the influence of time and temperature of incubation on heat resistance and activity following the heating of certain commonly used Swiss cheese starter organisms.

The literature on influence of time and temperature of incubation on heat resistance of bacteria has been reviewed briefly by Elliker (4) and by Elliker and Frazier (5).

Numerous investigations have demonstrated that age of bacterial cells markedly influences their resistance to heat. Frazier *et al.* (7) have shown the importance of age of the cultures. The temperature inducing greatest heat resistance of vegetative cells has been found to vary with the type of organism. For example, Claydon (2) and Anderson and Meanwell (1) reported that *Streptococcus lactis* and a thermoduric streptococcus, respectively, showed greatest heat resistance when grown at temperatures below the

Received for publication May 21, 1938.

[1] This work has been aided by a grant from the Wisconsin Alumni Research Foundation.

optimum for growth. Dorner and Thöni (3) demonstrated that there was little difference in heat resistance of cultures of *Bacterium acidi propionici* grown at 22° and at 30° C. Unpublished results obtained at the Washington laboratories of the Bureau of Dairy Industry indicated that propionic acid bacteria grown at temperatures near their optimum were more resistant to heat than those grown at lower temperatures. Results reported by Frazier and coworkers (7), and by Elliker and Frazier (5) demonstrated that with certain organisms incubation at temperatures near or above the optimum for growth might result in greater heat resistance and activity following heating than would result from incubation at a lower temperature.

EXPERIMENTAL

In this investigation on the heat resistance of non-spore forming, thermoduric bacteria, *Lactobacillus helveticus* 39aW and *Streptococcus thermophilus* C-3, the organisms used by Frazier *et al.* (7), were used. In part of the work several other species of *Lactobacillus* and *Streptococcus* were employed.

The usual method of measuring heat resistance of a culture is to determine the number of organisms present both before and after heat treatment by plate counts and from these calculate the percentage surviving. This method is not adapted for the study of the heat resistance of *L. helveticus* and *Str. thermophilus* because of the tendency of these organisms to form long chains, particularly in young cultures and at high temperatures. For this reason activity following heating of the culture was followed by direct microscopic counts, and by acid titrations made before and at varying intervals following the heat treatment. This method measures the ability of the culture to grow and ferment after treatment. The main disadvantage is that it does not determine the percentage survival of cells. In these studies, a measure of the activity following heating was used more than the plate count method.

The cultures were carried in tubes of sterile reconstituted skim milk, always prepared from the same lot of skim milk powder. Unless otherwise indicated, one per cent of inoculum was used. Stock cultures were incubated at 37° C. for 16 hours after which they were kept at 10° C. until the next transfer one week later. Determination of heat resistance or of activity after heating of a culture was carried out on an inoculating culture which was prepared by transfer of one per cent of inoculum from the most recent stock or mother culture to 100 cc. of milk. Unless otherwise indicated the incubation was the same as that of the stock or mother culture. Following incubation, 0.25 per cent of culture was transferred from the inoculating culture to a liter flask containing 450 cc. of freshly steamed and cooled sterile reconstituted skim milk. The temperature of the milk in the flasks was raised in a period of about five minutes to the temperature of

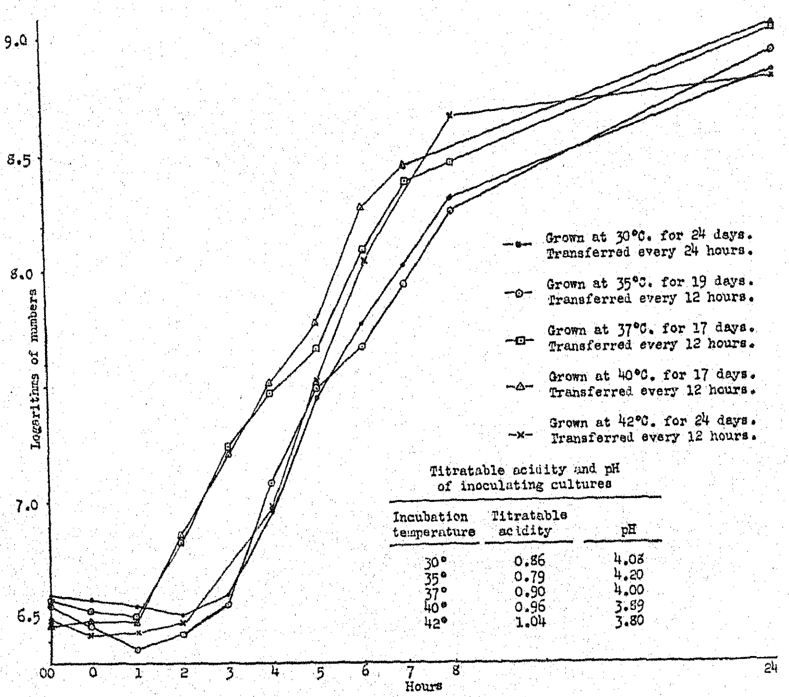
heat treatment, usually 60° C., maintained for 30 minutes and then lowered to the temperature of subsequent incubation. It was believed that this treatment reasonably simulated the exposure which starter cultures might receive in the manufacture of Swiss cheese. Incubation following heat exposure was carried out in thermostatically controlled water baths. The rate of growth following the heat treatment of the cultures was determined by direct microcsopic counts of living cells according to the method of Frazier and Boyer (6), and also by determinations of pH and titratable acidity. Samples were removed for these determinations before and at definite intervals following the heat treatment.

Influence of temperature of incubation on activity following heat treatment

In this experiment cultures were carried at 30°, with transfers every 24 hours, and at 35, 37, 40 and 42° C. with transfers every 12 hours. These are incubation periods commonly used in carrying starter cultures in actual practice. It was believed that growth at temperatures in this range might yield some knowledge of the effect of incubation temperature on heat resistance of the organisms, and that consequently the studies might be limited to the influence of two or three different temperatures. Such a procedure would then allow more detailed and better controlled experiments than would be possible if a greater number of temperatures were used. It was realized that the incubation temperatures and times used resulted in cultures whose maturity, as indicated by titratable acidity and pH of inoculating cultures, varied to some extent. Nevertheless, results obtained by the carefully controlled methods used should give some indication of the effect of temperature and should suggest whatever subsequent modifications of methods might be necessary.

Figures 1 and 2 show the relative activity following heat treatment of cultures carried at the various temperatures. Growth curves constructed from direct counts indicate the rate of growth at 37° C. following heat treatment. Also included are titratable acidities and pH values for the first eight hours and the 24th hour, as well as acidities of the inoculating cultures. Samples removed from the flasks of milk before heat treatment are designated in the figures as 00 hour samples; those removed immediately after heat treatment and cooling to 37° C. are designated as 0 hour samples.

The activity of the inoculating culture following heat treatment could be predicted from its titratable acidity at the time it was used. Repeatedly inoculating cultures with low titratable acidities were found to be inactive after the heat treatment. The titratable acidity produced in an inoculating culture within a given time at a given temperature, therefore, indicates how active that culture will be following subsequent heat treatment. Frazier *et al.* (7) have emphasized the importance of a certain titratable acidity in



		1	2	3	4	5	6	7	8	24
pH	30°	6.36	6.36	6.34	6.29	6.21	6.09	5.83	5.53	3.72
	35°	6.34	6.33	6.31	6.28	6.21	6.07	5.86	5.56	3.74
	37°	6.36	6.34	6.30	6.27	6.18	6.01	5.72	5.35	3.72
	40°	6.36	6.34	6.30	6.25	6.16	5.93	5.65	5.26	3.66
	42°	6.36	6.36	6.32	6.26	6.15	6.00	5.73	5.41	3.74
Titratable acid	30°	0.15	0.15	0.15	0.16	0.17	0.19	0.22	0.28	1.20
	35°	0.15	0.15	0.15	0.16	0.17	0.19	0.22	0.26	1.14
	37°	0.15	0.15	0.15	0.16	0.18	0.21	0.25	0.31	1.19
	40°	0.15	0.15	0.16	0.18	0.19	0.22	0.26	0.34	1.20
	42°	0.14	0.15	0.15	0.16	0.17	0.20	0.22	0.28	1.21

FIG. 1. Growth curves and acid production at 37° C. of cultures of *Lactobacillus helveticus* grown at different temperatures and heat shocked at 60° C. for thirty minutes.

bulk starter cultures within a given incubation time at a given incubation temperature if the starter organisms are to be active during the manufacture of Swiss cheese.

Examination of Figure 1 leaves little doubt that the 37° and 40° cultures were superior to the others. The pH and titratable acidity of the respective inoculating cultures indicate that those grown at 30° and 35° had not reached as high a stage of maturity as had the 37°, 40° and 42° C. cultures. The activity of all cultures except the 42° was directly proportional to the titratable acidities of the inoculating cultures. This indicates that the maturity of the cells in the inoculating culture may influence their subsequent heat resistance. The counts were higher in those cultures grown at the lower temperatures, therefore the original number of organisms present before heat treatment did not greatly influence the results.

TABLE 1

Influence of incubation temperature of mother cultures on the activity of Lactobacillus helveticus and Streptococcus thermophilus at 37° C. (98.6° F.) following heat shocking

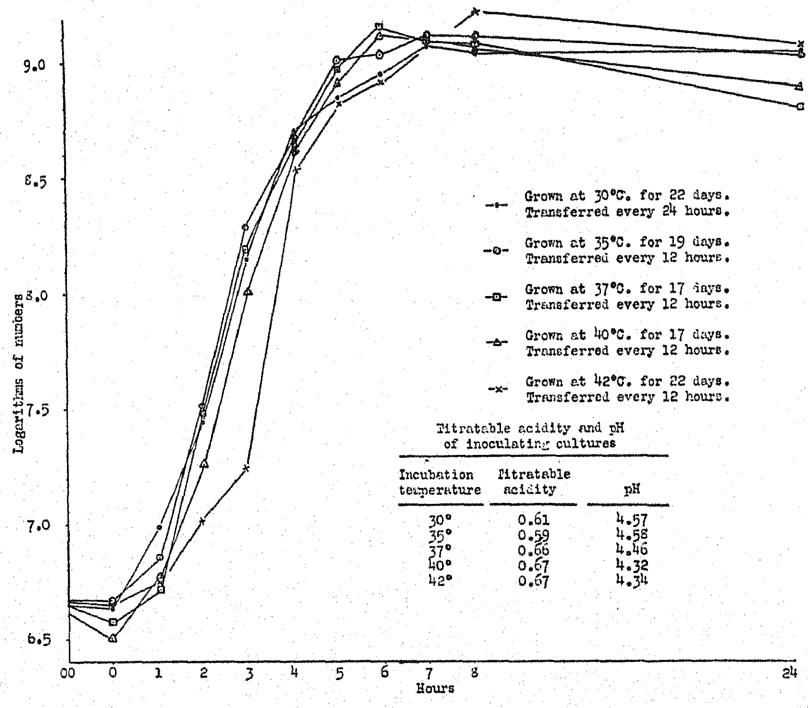
Culture	Incubation time and temperature	Number of transfers at respective temperatures	Titratable acid of inoculating culture	Time and temperature of heat shocking	Time of incubation following heat shocking	Drop in pH
			Per cent		*Hours*	
L. helveticus	12 hrs. 37°	1	0.87	30′ 65°	13	.36
	12 hrs. 40°	1	0.99	30′ 65°	13	.29
L. helveticus	12 hrs. 37°	34	0.90	30′ 60°	6	.35
	12 hrs. 40°	34	0.96	30′ 60°	6	.43
L. helveticus	12 hrs. 37°	58	0.92	30′ 62.5°	8	.86
	12 hrs. 40°	58	1.11	30′ 62.5°	8	.98
Str. thermophilus	12 hrs. 37°	1	0.63	30′ 65°	5	.22
	12 hrs. 40°	1	0.67	30′ 65°	5	.00
Str. thermophilus	12 hrs. 37°	4	0.64	30′ 70°	12	.36
	12 hrs. 40°	10	0.68	30′ 70°	12	.04
Str. thermophilus	12 hrs. 37°	16	0.64	30′ 60°	5	1.00
	12 hrs. 40°	16	0.67	30′ 60°	5	.86
Str. thermophilus	12 hrs. 37°	24	0.66	30′ 65°	5	.16
	12 hrs. 40°	24	0.65	30′ 65°	5	.01

Counts and pH values following heating of cultures of *Str. thermophilus*, shown in Fig. 2, indicated that the 30° and 35° cultures initiated growth first, closely followed by the 37° C. culture. The acidities of the 30° and 35°, and possibly the 37° cultures, are lower than acidities of cultures grown at the other temperatures.

The differences in rate of acid formation at 37° C. following heat treatment were slight, yet they were significant. This fact was emphasized in later experiments in which cultures were incubated at temperatures near their maximum following heat treatment.

Effect of incubation of L. helveticus and Str. thermophilus at 37° and 40°, with transfers every 12 hours, on their activity following heat treatment

The results shown in Figures 1 and 2 demonstrate that growth at 37° and 40° C. appeared to increase slightly the heat resistance of *L. helveticus* and that there was a slight superiority of the 40° over the 37° culture. From the results of Frazier *et al.* (7) and those obtained in this work, it seemed logical to assume that if the effect of temperature on heat resistance of



Titratable acidity and pH of inoculating cultures

Incubation temperature	Titratable acidity	pH
30°	0.61	4.57
35°	0.59	4.58
37°	0.66	4.46
40°	0.67	4.32
42°	0.67	4.34

pH	30°	6.36	6.33	6.14	5.87	5.31	5.06	4.92	4.83	4.12
	35°	6.34	6.33	6.14	5.39	5.31	5.06	4.92	4.83	4.21
	37°	6.34	6.32	6.16	5.89	5.30	5.10	4.95	4.82	
	40°	6.34	6.33	6.21	5.96	5.38	5.13	4.97	4.82	
	42°	6.36	6.35	6.25	5.99	5.48	5.16	4.97	4.88	4.12
Titratable acid	30°	0.15	0.15	0.19	0.26	0.35	0.40	0.44	0.48	0.76
	35°	0.15	0.16	0.18	0.25	0.35	0.40	0.45	0.47	0.77
	37°	0.15	0.16	0.21	0.27	0.37	0.41	0.47	0.48	0.78
	40°	0.15	0.15	0.19	0.25	0.34	0.41	0.45	0.48	0.77
	42°	0.15	0.15	0.17	0.22	0.32	0.39	0.43	0.46	0.77

FIG. 2. Growth curves and acid production at 37° C. of cultures of *Streptococcus thermophilus* grown at different temperatures and heat shocked at 60° C. for thirty minutes.

these organisms was significant, carefully controlled, parallel studies on cultures carried at 37° and 40° should bring out differences between them.

Because the higher incubation temperatures, such as 40° C. and above, apparently were unfavorable for *Str. thermophilus,* growth of this organism at 37° and 40° might result in an effect opposite to that obtained with *L. helveticus.* Accordingly, these two organisms were carried for a varying number of transfers at 37° and 40° with transfer every 12 hours. In certain cases cultures were heat shocked after only one transfer, in other cases after numerous transfers. The temperature of heat shocking was altered in certain experiments in order to emphasize differences not brought out by a less severe heat exposure. Because the presentation of all the pH values and counts would require a large number of tables, the change in pH

during a definite period following heat treatment is tabulated rather then the pH values, and counts for every individual hourly determination. It will be observed that in the tables the intervals between time of heat shocking and time of determination of acidity are varied in proportion to rate of acid formation following heat treatment.

The results shown in Table 1 indicate that following one transfer at the two temperatures, the 37° *L. helveticus* culture was better able to withstand the heat treatment, but after 34 transfers, the 40° appeared superior to the 37° culture. After 58 transfers, the 40° C. culture was still superior. It is apparent, then, that some change had taken place in the comparative resistance of the two cultures during continuous transfer at the two temperatures. *Str. thermophilus* exhibited a behavior altogether different from that of *L. helveticus.* Results in Table 1 indicate that after one transfer, the 37° *Str. thermophilus* culture was decidedly the more resistant to heat exposure. In the five hours following heat shocking the pH of the 37° culture dropped 0.22 while no measurable acid was formed in the 40° culture. After numerous transfers, similar results were obtained. Heat shocking at 65° rather than 60° emphasized this difference. After the twenty-fourth transfer, the 37° culture lowered the pH a total of 0.16 during the first five hours after heat shocking while the 40° culture lowered it only 0.01.

It was demonstrated further that the greater heat resistance of the 40° *L. helveticus* culture was not eliminated by one transfer at a temperature of 37° C. After the mother cultures had been carried at 37° and 40° C., respectively, for 60 days, one inoculating culture was inoculated from the 37° mother culture and incubated at 37° C. for 12 hours. A second inoculating culture was inoculated from the 40° mother culture and incubated at 40° for 12 hours. A third was inoculated from the 40° mother culture and incubated at 37° C. for 12 hours. The 40° culture grown continuously at 40° was more resistant than the same 40° culture grown for one transfer at 37°. However, both of these cultures were more resistant than the 37° culture grown continuously at 37° C.

Effect of continuous transfer of mother cultures at 37° and 40° C. on their activity at temperatures near their maximum after heat shocking

In previous experiments a temperature of 37° C. was employed following heat shocking to compare ability of cultures to develop following exposure to heat. In the manufacture of Swiss cheese any organisms which are to develop in the earlier stages (the time when cultures of *Str. thermophilus* and lactobacilli should be active) must be able to initiate growth at the high temperature of the curd at the time it is placed in the press and must continue to grow at the high temperatures which are maintained while the

cheese is on the press. Results above show definite but not pronounced differences between *L. helveticus* grown at 37° and at 40° C. Nevertheless field results and those of Frazier *et al.* (7) demonstrated that a slightly higher incubation temperature of bulk starters resulted in greater activity of organisms when the curd was on the press. It was considered possible that the apparent superiority of the 40° over the 37° C. culture might be due to the fact that the change in a culture produced by continued growth at the higher incubation temperature was the ability to grow well subsequently at higher temperatures (*e.g.*, near the maximum temperature) rather than any effect on survival and on activity of cells at 37° after heating. For this reason in this and in certain of the following experiments, after the cultures were heat shocked at 60° C. for 30 minutes, they were incubated at temperatures near their maximum. Counts and pH determinations were made at definite intervals to compare development at the higher tempera-

TABLE 2

Influence of incubation temperature of mother cultures on activity of Lactobacillus helveticus and Streptococcus thermophilus at temperatures near their maximum following heat shocking at 60° C. for thirty minutes

Culture	Incubation time and temperature	Number of transfers at respective temperature	Titratable acid of inoculating culture	Temperature of incubation following heat shocking	Time of incubation following heat shocking	Drop in pH
			Per cent	*° C.*	*Hours*	
L. helveticus	12 hrs. 37°	1	0.88	44	8	.60
	12 hrs. 40°	1	1.06	44	8	.35
L. helveticus	12 hrs. 37°	18	0.80	44	8	.09
	12 hrs. 40°	18	1.03	44	8	.59
L. helveticus	12 hrs. 37°	70	0.95	44	8	.23
	12 hrs. 40°	70	1.12	44	8	.77
L. helveticus (a)	12 hrs. 37°	96	0.89	44	9	.04
(b)	12 hrs. 40°	96	1.03	44	9	.45
(c)	14 hrs. 37°	96	1.00	44	9	.05
(d)	10 hrs. 40°	96	0.94	44	9	.43
Str. thermophilus	12 hrs. 37°	1	0.70	48	4	.73
	12 hrs. 40°	1	0.70	48	4	.68
Str. thermophilus	12 hrs. 37°	140	0.68	48	4	.56
	12 hrs. 40°	140	0.71	48	4	.31
Str. thermophilus	12 hrs. 37°	1	0.71	48	4	.88
	12 hrs. 37°	150	0.70	48	4	.51

(a) and (c) = Inoculated from mother culture carried at 37° C. for 48 days and transferred every 12 hours. Table shows incubation time and temperature of inoculating cultures.

(b) and (d) = Inoculated from mother culture carried at 40° C. for 48 days and transferred every 12 hours. Table shows incubation time and temperature of inoculating cultures.

tures following heating. Preliminary tests indicated that the most suitable incubation temperatures for such experiments were 44° for *L. helveticus* and 48° C. for *Str. thermophilus.*

The results, shown in Table 2, demonstrate certain differences in cultures of *L. helveticus* carried at 37° and 40° which were not brought out by incubation at lower temperatures following heating. After the first transfer of the mother cultures at 37° and 40°, the 37° appeared more resistant. After 18, 70 and 96 transfers, the 40° culture was without doubt the more active at 44° after the exposure to heat. The change in activity following heating was in the same direction as in previous experiments (*i.e.,* after numerous transfers the 40° appeared more heat resistant than the 37° culture). After the ninety-sixth transfer, the 37° mother culture was transferred to two inoculating cultures which were incubated at 37° for 12 and 14 hours, respectively. The 40° mother cultures were transferred to inoculating cultures which were incubated at 40° C. for 10 and 12 hours, respectively. The titrations of the 12 hour, 37° and the 10 hour, 40° cultures were 0.89 per cent and 0.94 per cent respectively. Those of the 14 hour, 37° and 12 hour, 40° cultures were 1.00 and 1.03 per cent. In spite of the close approximations in titratable acidities of mother cultures, the 40° culture lowered the pH after heating 0.43 and 0.45 as compared to 0.04 and 0.05 for the 37° culture. The greater maturity of the 40° inoculating cultures apparently was not responsible for their greater resistance and their activity at 44° following heating. Similar differences in heat resistance were obtained with stock cultures carried at 37° and 40°, respectively, and transferred every week.

The results obtained with *Str. thermophilus,* shown in Table 2, on the whole are similar to those obtained when an incubation temperature of 37° rather than 48° C. was employed following heat treatment.

When microscopic counts were made of cultures incubated at temperatures near their maximum following heating, irregular results were often obtained because of the formation of extremely long entangled chains and because unusually high numbers of the cells were gram-negative, due possibly to a change in staining properties after rapid growth at the high temperature.

Influence of time and temperature of incubation on activity of L. helveticus and Str. thermophilus at temperatures near their maximum following heat treatment

Previous experiments were concerned chiefly with the influence of incubation temperature and although certain allowance had been made for it, the fact soon became evident that greater emphasis must be placed on effect of time of incubation. The cultures of *L. helveticus* used for this experiment were being transferred daily, incubated for 14 hours at 37° or 40° and then placed at 10° for 10 hours until time for the next transfer. Those of *Str. thermophilus* were being transferred daily, incubated for 12 hours at 37° and 40° and then placed at 10° for 12 hours until time for the next

transfer. Results indicated that 40° cultures of *L. helveticus* and 37° cultures of *Str. thermophilus* were superior in each case. But as in earlier experiments, it was believed possible that an incubation time of 14 hours for *L. helveticus* and 12 hours for *Str. thermophilus* was not the optimum. Accordingly, fresh transfers of these two organisms, carried in the manner described, were used to prepare inoculating cultures which were then incubated at 37° and 40° for periods varying from 6 to 16 hours. The inoculating cultures were inoculated at such intervals that they might all be removed and heat shocked simultaneously. Titrations and pH determinations made of inoculating cultures indicated their relative maturity. Table

TABLE 3

Influence of time and temperature of incubation on activity of Lactobacillus helveticus at 44° C. following heat shocking at 60° C. for thirty minutes

Time and temperature of incubation of mother culture	Number of daily transfers of mother culture by this method	Time and temperature of incubation of inoculating culture	Titratable acid of inoculating culture	Drop in pH during first eight hours following heat shocking
			Per cent	
14 hrs. 37° 10 hrs. 10° ...	30	7 hrs. 37°	0.49	.00
	30	12 hrs. 37°	0.96	.29
	30	16 hrs. 37°	1.14	.26
14 hrs. 40° 10 hrs. 10° ..	30	7 hrs. 40°	0.64	.01
	30	12 hrs. 40°	1.10	.36
	30	16 hrs. 40°	1.26	.23
14 hrs. 37° 10 hrs. 10° ...	65	8 hrs. 37°	0.41	.03
	65	12 hrs. 37°	0.86	.42
	65	16 hrs. 37°	1.11	.46
14 hrs. 40° 10 hrs. 10° ..	65	8 hrs. 40°	0.56	.05
	65	12 hrs. 40°	1.04	.51
	65	16 hrs. 40°	1.25	.39

3 demonstrates that under the conditions employed in this experiment, the time of incubation definitely influenced the ability of *L. helveticus* to develop after heat shocking. Twelve and 16 hour cultures of *L. helveticus* were far more active following heat treatment than were the seven and eight hour cultures. As shown in Table 4, there was little measurable difference in heat resistance of cultures of *Str. thermophilus,* grown for periods of 6, 12, and 16 hours, respectively. In another trial there was little difference between 8 and 16 hour, 37° cultures of *Str. thermophilus,* and no significant difference between 8 and 16 hour, 40° cultures.

DISCUSSION

The results indicated that when *L. helveticus* was carried at temperatures of 30°, 35°, 37°, 40°, and 42° C. for the incubation periods commonly employed in actual practice for starter cultures of this organism and other related lactobacilli, the heat resistance of cultures incubated at temperatures of 37° and 40° was greater than that of cultures incubated above or

TABLE 4

Influence of time and temperature of incubation on activity of Streptococcus thermophilus at 44° C. following heat shocking at 60° C. for thirty minutes

Time and temperature of incubation of mother culture		Number of daily transfers of mother culture by this method	Time and temperature of incubation of inoculating culture	Titratable acid of inoculating culture	Drop in pH during first eight hours following heat shocking
				Per cent	
12 hrs. 37°	12 hrs. 10°	29	8 hrs. 37°	0.58	1.03
		29	12 hrs. 37°	0.68	1.02
		29	16 hrs. 37°	0.77	1.02
12 hrs. 40°	12 hrs. 10°	29	8 hrs. 40°	0.62	1.03
		29	12 hrs. 40°	0.72	.76
		29	16 hrs. 40°	0.77	.92
12 hrs. 37°	12 hrs. 10°	53	6 hrs. 37°	0.50	1.06
		53	12 hrs. 37°	0.71	1.05
		53	16 hrs. 37°	0.78	1.11
12 hrs. 40°	12 hrs. 10°	53	6 hrs. 40°	0.52	1.06
		53	12 hrs. 40°	0.73	1.08
		53	16 hrs. 40°	0.79	1.05

below these temperatures. When cultures were carried at 37° and 40° and transferred every 12 hours, it was found that the first transfer of the 37° cultures was fully as resistant as and sometimes more resistant to heat than the first transfer of the 40° culture. Titrations of the inoculating cultures showed that the 40° culture was more mature than the 37° culture. As the consecutive 12 hour transfers at the two respective temperatures were continued, the 40° culture gradually became the more resistant. These results indicated, then, that the higher temperature of incubation was responsible for the increased heat resistance. The 40° was more mature at the time of every transfer than the 37° culture and any advantage in heat resistance due to greater maturity may have accumulated over a number of successive transfers. On the other hand, the 40° culture was more mature at the first transfer yet less heat resistant than the 37° culture. This fact would suggest that maturity of the cultures was not a major factor in the development of differences in heat resistance between 37° and 40° cultures after repeated transfer. The results strongly indicate, then, that the higher incubation temperature was primarily responsible for greater heat resistance. Differences in numbers of organisms in the respective cultures before heating were not great enough to cause significant differences in the numbers surviving heat treatment.

Because the greater heat resistance of the 40° culture was not lost by one transfer at 37°, it would appear that the increased heat resistance of the 40° cells may have been permanent enough to survive several generations of growth at the lower temperature.

Incubation of heat shocked cultures at temperatures near their maximum emphasized the difference between 37° and 40° cultures of *L. helveti-*

cus. Results to appear in a later paper indicate that the number of active cells present in a culture largely govern its ability to develop at 44° C.

Streptococcus thermophilus, when carried at different temperatures by the same methods employed for *L. helveticus* demonstrated an entirely different behavior. Growth at 30°, 35° and 37° C. yielded cultures which were more active following heat treatment than were those grown at 40° and 42° C. When cultures of this organism were grown at 37° and 40° and were transferred every 12 hours, the 37° culture was more resistant than the 40°, both after one and after numerous transfers. These heat resistant studies were made on cultures which were about at the stage of maximum heat resistance. Titratable acidities of inoculating cultures indicated that possibly the greater amount of acid produced by the 40° as compared with the 37° culture had an injurious effect on the cells and therefore lowered their heat resistance. However, when cultures were incubated at 37° and 40° for periods varying from six to 16 hours, no great difference in heat resistance was obtained. This fact would minimize the influence of the greater amount of acid produced in a 12 hour incubation period at the higher temperatures on the heat resistance of *Str. thermophilus*. The results, as a whole, demonstrate that growth of *Str. thermophilus* at lower temperatures results in greater activity and heat resistance than growth at the higher temperatures used in these studies. *Str. thermophilus* has a higher maximum temperature and was apparently influenced less by the incubation time and type of milk in which it was grown than *L. helveticus*. This explains why it is easier to obtain active starter cultures of *Str. thermophilus* than of *L. helveticus*. The importance of the culture medium in developing active starter cultures will be discussed in a following paper.

The results obtained by incubation of cultures of *L. helveticus* and of *Str. thermophilus* at temperatures near their maximum following heat shocking explain why certain Swiss cheese starter cultures which show no outward differences in activity still vary so widely in their ability to develop at the high temperatures prevailing in Swiss cheese on the press. The high temperature effects a rather delicate balance in that it determines largely whether or not the starter organisms will develop at an early hour. If the culture is weak, it may not develop until the temperature falls to a favorable level. The consequent slow acid development in the curd on the press may result in serious defects in the cheese.

SUMMARY

1. When *L. helveticus* was carried for numerous transfers at different temperatures by methods similar to those commonly employed in handling starter cultures of this organism, those cultures carried at 37° and 40° were more active following heat treatment than were cultures carried at 30°, 35° and 42° C.

2. The 37° cultures of *L. helveticus* were more heat resistant than the 40° C. cultures after the first 12 hour transfer at the respective temperatures, but after numerous, successive 12 hour transfers at the respective temperatures, the 40° was more resistant than the 37° culture. This increased resistance of the 40° culture was not lost by one transfer at a lower temperature.

3. Cultures of *Str. thermophilus* carried for numerous successive transfers at different temperatures by the same methods used for *L. helveticus* showed greater heat resistance when grown at 30°, 35° and 37° than at 40° or 42° C. The 37° cultures were more active than were the 40° C. cultures of *Str. thermophilus* after both one and numerous successive 12 hour transfers at the respective temperatures.

4. Heat treatment in the usual manner, followed by incubation of the respective cultures at temperatures near their maximum and comparison of their subsequent rates of growth and acid production, emphasized the differences in activity following heat shocking of cultures of *L. helveticus* and *Str. thermophilus*.

5. Cultures of *L. helveticus* incubated at 37° and 40° C. for 12 to 16 hours were far more heat resistant than cultures incubated at 37° and 40° C. for seven and eight hours.

6. There was no marked difference in activity following heat treatment of cultures of *Str. thermophilus* incubated at 37° C. for periods varying from six to 16 hours, the range of incubation periods usually employed in growing starter cultures of this organism.

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ERRATUM

July, 1938, page 335, line 17, should read as follows: "the preparation of 0.05 N KOH and C_2H_5ONa solutions."

VOLUME XXI DECEMBER, 1938 NUMBER 12

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Published by the
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E. "The incidence of milk samples yielding acid and gas in McConkey broth at 30° C."—C. D. Oxley.

A test of 205 samples of milk by the methylene blue test, the "presumptive coli" test at 37° and at 30° C. showed that the last was responsible for more failures than the others. This test picks out more "poor" samples than any other.

F. "Statistical examinations of the results of a co-operative experiment on methylene blue reduction tests and bacterial plate counts"—H. Barkworth and A. T. R. Mattick.

A comparison of the plate count and methylene blue reduction test showed that 87 per cent of samples failed or passed both tests. The correlation between plate count and reduction time was lower in winter, although here a high correlation was found with high plate count. Four laboratories testing common samples agreed on plate counts and reduction times at 37° C., but gave differences with the keeping quality test and the reduction test at 15.5° C.

G. "Some experiments on the value of the Methylene Blue Test and the Resazurin test for the grading of milk during winter"—S. B. Thomas.

A comparison of the old method of carrying out the methylene blue test with the Wilson modification showed that half hourly inversion decreased the reduction time on the average by 5 hours.

The mean reduction time for samples held in the refrigerator at 40° F. overnight was 3½ hours longer than for duplicates held overnight at 60° F.

The variations in the reduction times of duplicate tubes observed by one worker increased in number and magnitude as the reduction times increased. Quintuplicate tests by one worker, taking readings every five minutes, gave a mean coefficient of variation of reduction times as low as 0.7 per cent, whereas the mean C.V. obtained by four workers using separate water baths was 6.5 per cent, and for duplicate tests at each of four laboratories 9.4 per cent. A comparison of the Resazurin test with the methylene blue test showed that the former is worthy of further investigation.

H. "The effect of storage time and temperature on the methylene blue reduction test for milk"—M. Braz and W. A. Hoy.

The importance of time and temperature of storage is emphasized. In practice wide variations in temperature may occur. A series of tests showed that storage for 12 hours at 65° F. is equivalent to 18 hours at 60° F. A temperature of 40–50° F. has a considerable retarding effect on the test, but a storage temperature of 60° F. reveals a milk in its true character.

I. "A comparison between the methylene blue reduction test and the plate count with changing conditions of milk production and with changing conditions of storage of milk samples before testing"—A. A. Nichols and C. J. Jackson.

A study of the comparative sensitivity of the plate count and methylene blue reduction test to bad methods of production is described. The latter is more sensitive if the samples are held at 72° F. and (for dirty conditions) at room temperature. A short holding followed by refrigeration reveals very little difference. Testing immediately after milking or after storage at low temperatures showed that the plate count provided the better index.

J. "A comparison of the results of different methods of analysis and of sampling of milk during 1937"—M. E. Pirrie.

The present Accredited Standard was found to be more severe than the old Grade A standard on account of the holding of small samples at atmospheric temperature for 12 or 18 hours. Both plate count and methylene blue tests give similar results if samples are held under identical conditions. Icing of samples during transit and holding is recommended.

K. "Mastitis in relation to the methylene blue reduction test"—J. G. Davis and J. McClemont.

Mastitis has a much more marked effect on plate count than on methylene blue reduction time. Methylene blue is toxic to *Str. agalactiae* so that it is unlikely that this organism will either proliferate or reduce the dye in the test. The slightly shorter reduction times due to mastitis may be attributed to the higher cell content and to the increased flora. Holding the samples at 4° C. or 15.5° C. did not appear to increase the differentiation between infected and non-infected samples. The methylene blue test is of no use for the detection of mastitis.

L. "Indirect methods of mastitis diagnosis"—M. Zein-el-Dine and S. J. Rowland.

Clinical examination (by palpation) could only detect 7% of the cases. "Clots" or flakes of the fore-milk, and brom-thymol-blue papers could detect 12 and 14% respectively of the positive quarters. No "false positives" could be found with these three tests.

The brom-cresol-purple papers could detect 61% of the positive cases and classed 27% as doubtful, and only 12% could be passed as normal; but, on the other hand, it classed 16% of the negative cases as positive and 22% as doubtful.

The centrifuge deposit test could detect 55% of the positive cases and classed 23% as doubtful, while classifying only 3% as false positives. This

test gave 25% false doubtfuls. The catalase test was useless as it detected less than half of the positive cases, and gave many false positives and false doubtfuls.

The chloride test (digestion method) could detect 57% of the positive cases and gave no false positives. The casein number method detected 91% of the positive cases and gave 8% false positives.

The solids-not-fat in the fat-free milk is a good test for mastitis (solids-not-fat in fat-free-milk lower than 8.76%) 88% of the low solids-not-fat milks examined were found to be infected. "Physiologically low solids-not-fat milks" were thus found to be comparatively rare.

M. "The diagnosis of *Str. agalactiae* in a liquid selective medium"—S. J. EDWARDS.

A highly selective medium having the following composition: Lemco broth (pH 7) 1,000 ml., dextrose 5 g., crystal violet (purified) 0.1%, 1 ml., sodium azide 0.1 g., has been found to give good results. It is recommended for checking the clean section of a herd after a blood agar plate diagnosis has been carried out.

N. "Further studies of the aerobic spore-forming bacilli"—T. GIBSON AND L. E. TOPPING.

A provisional key to assist in the identification of the commonest species of aerobic spore-forming bacilli is presented. Barritt's modification of the Voges-Proskauer test and the production of acid or acid and gas from glucose are the main diagnostic criteria utilized. The key does not include obligate thermophiles or a few relatively uncommon organisms.

O. "The production of lactic acid from substances other than sugar by *L. casei*"—C. C. THIEL.

A strain of *L. casei* has been found to produce more lactic acid in pancreatic and peptic casein and milk digests than is accounted for by the sugar utilized. Also, in pancreatic and peptic casein digests to which no sugar is added, a considerable production of lactic acid (from 0.10 to 0.28 g. per 100 ml.) occurs. A casein suspension does not support growth; added alanine does not increase the lactic acid production in the digests.

Discrepancies between sugar utilized and acid produced do not occur in separated milk and separated milk plus yeast.

P. "The effect of sterilization upon sugars"—J. G. DAVIS AND H. J. ROGERS.

Autoclaving sugar solutions for 30 minutes at 120° C. is very much more destructive than "momentary autoclaving," which is only slightly more

destructive than the usual intermittent steaming method. Momentary autoclaving, unlike intermittent steaming, can be relied upon to sterilize media in tubes. Differences in fermentation tests due to heating the sugar in, or apart from, the medium do not seem to be significant. As a standard technique momentary autoclaving of all sugar broths at pH 6.6 is recommended.

BREEDING

562. Extending the Use of a Proved Sire. ALLAN K. BROWN, Guernsey Breeders' Journal, 54, 705, October 15, 1938.

Dr. Allan K. Brown, owner of Brown Ranch, Capitola, California, has practiced artificial insemination in his herd since 1937 and he says that the advantages of this method are:

1. Increased number of progeny obtainable from an ageing and proven sire.
2. Relief from overuse, particularly an old bull.
3. Overcoming physical defects, injuries, or disease in both female and male, such as adhesions in the bull, and cervitis in the cow.

The formula for diluting mediums is:

Water 100 CC.
Glucose 3%
With a pH of 7.5.

When the records indicate that several cows are due to come in heat within a period of one or two days the cow(s) coming in heat first are held over a day or two until the others come in heat. The first cow(s) of the group may then no longer accept the bull. However, experience has shown that conception will occur with considerable regularity if the cow is artificially inseminated at this time. One of the cows in heat is bred, the semen removed, diluted and a one cubic centimeter portion discharged into the opening of the cervix of the other cows by an inseminating syringe. Eight cows have been successfully bred by holding them over three days.

His results have been very satisfactory, as out of forty-seven cows bred, forty of them conceived the first time. Eighty per cent of the animals in the breeding herd of 125 females were bred to one bull. L.R.L.

FEEDS AND FEEDING

563. Legume and Grass Silages. O. M. CAMBURN, H. B. ELLENBERGER, J. A. NEWLANDER AND C. H. JONES. Vermont Agricultural Experiment Station Bul. *434*, May, 1938.

The data from one season's trials indicate that:

Legumes and grasses may be successfully ensiled either with or without molasses provided their dry matter contents range between 30 and 40 per cent and preferably as near to 35 per cent as may be.

A dry matter content of less than 30 per cent favors putrefactive fermentation, especially if molasses is not added; one of over 40 per cent tends to prevent tight packing in the silo and induces heating and spoilage.

The ensiling of legumes or grasses is not advisable under ordinary farm conditions unless molasses or acid are added, for the reason that it is hard to control the dry matter content of silage.

The addition of two per cent (40 pounds per ton) of molasses to ensiled timothy and of three or four per cent (60 to 80 pounds per ton) to ensiled alfalfa tends to induce fermentation and to decrease the likelihood of spoilage due to the presence of too much or too little moisture. The odor and palatability of such silages are improved when molasses is used and their feeding value may be slightly enhanced.

The minerals, proteins, and total nutrients are better preserved by ensiling than by ordinary haying methods.

Close packing and exclusion of air are essential to the proper preservation of grass silages, especially those somewhat low in moisture due to wilting after cutting or to maturity of the crop.

An addendum report attached to this bulletin sets forth the results secured in an extensive survey of practical operations throughout the Northeast.

O.M.C.

564. Digestibility of Alfalfa, Timothy, and Soybeans as Silages and as Hays. J. A. NEWLANDER, H. B ELLENBERGER, O. M. CAMBURN AND C. H. JONES. Vermont Agr. Exp. Sta. Bul. *430*, March, 1938.

Coefficients of digestibility have been determined with dairy cows for 41 lots of silages and hays made from the 1936 crops of alfalfa, timothy and soybeans. Silages were made both with and without the addition of molasses to freshly cut and slightly wilted cuttings. Hays were made by natural sun curing and by artificial drying. The alfalfa and the timothy were cut at two stages of maturity.

On a dry matter basis most of the hays carried less ether extract and ash than the silages and more nitrogen-free extract. The artificially dried hays contained less fiber than the silages and sun cured hays.

The digestion coefficients of the hays, especially those which were artificially dried, were slightly higher in nitrogen-free extract but significantly lower in ether extract, especially in the case of the sun cured hay. Crude fiber and nitrogen-free extract seemed slightly more digestible in the silages to which molasses was added than in those not so treated.

On a dry-matter basis the silages carried slightly more digestible protein than did the hays. The artificially dried hays carried the most total digestible nutrients, followed in order by the molasses silages, the silages without molasses treatment and the sun cured hays, the latter two being about equal.

O.M.C.

565. The Mineral Needs of Farm Animals. Departments of Animal Industry and Dairy Husbandry, OHIO AGR. EXP. STA., Wooster, O. Ohio Exp. Sta. Spec. Circ. *49*. 1937.

The Vitamin Needs of Farm Animals. IBID. Spec. Circ. *52*. 1938.

These two companion circulars present in popular style the requirements of livestock for the various minerals and vitamins and make practical recommendations as to how these requirements can be met. W.E.K.

566. Nutritional Requirements of Pregnant and Lactating Rats Studied by the Self-selection Method. CURT. P. RICHTER AND BRUNO BARELARE JR., Henry Phipps Clinic, Johns Hopkins Hospital, Baltimore, Md. Proc. Amer. Physiol. Soc., Amer. J. Physiol., *123*, 1, p. 170, July, 1938.

Ten female rats were allowed to select their food ad libitum from the following 11 substances; casein, sucrose, olive oil, sodium chloride, dibasic sodium phosphate, calcium lactate, potassium chloride, dried baker's yeast, cod liver oil, wheat germ oil, and water.

These animals gave birth to normal litters and nursed most of them until they were weaned 25 days later. The changes in appetite for the 11 substances were strikingly similar in the 10 animals. It was observed that the animals voluntarily ingested large amounts of fat; in fact, over half (52.6%) of the calories were furnished by fat. The fat consumption increased during pregnancy and lactation, supplying 65 per cent of the calories at the end of lactation. Protein furnished 22.3 per cent of the calories before mating, 28.1 per cent at the end of gestation, and 23.8 per cent at the end of lactation. The appetite for sodium chloride, dibasic sodium phosphate, and calcium lactate showed striking increases during pregnancy and lactation. The appetite for wheat germ oil and cod liver oil remained essentially the same. The number of calories increased from 45.3 per day before mating to 58.8 at the end of gestation and to 118.3 at the end of lactation.

The fact that the animals grew and reproduced with as great success as on the McCollum diet, in spite of lower solid food and caloric intake, is evidence of the efficiency of the self selection method in the rat. D.L.E.

567. The Effect of Different Per Cents of Protein in the Diet in Successive Generations. JAMES R. SLONAKER, Dept of Physiology, Stanford University, California, Amer. J. Physiol. *123*, 2, p. 526, August, 1938.

Five groups of rats and their succeeding six generations were fed rations containing the following per cents of protein, fats and carbohydrates respectively: I—10.3, 12.2, 77.5; II—14.2, 14.2, 71.6; III—18.2, 15.9, 65.9; IV—22.2, 17.8, 60.0; V—26.3, 19.7, 54.0.

The animals comprising these successive generations were all kept in the same room and under the same environmental conditions as their ancestors. Although the animals in group I were smallest at birth and grew slower (both sexually and in skeletal growth) than any of the other groups, their life span was unusually long. Group V grew the fastest up to 70 days of age and attained the greatest final length. On the other hand, the greatest prenatal development took place among the rats fed 18.2 per cent protein. They also proved to be the best mothers.

Protein in the diet equal to, or in excess of, 18.2 per cent interfered with reproduction by increasing sterility. Such a diet also tended to shorten the breeding period and increase the size of the kidneys. In other words, the metabolic processes were quite generally speeded up by increasing the percentage of protein in the ration. The amounts of protein in the rations studied in these trials had no effect on the number of young born or on the sex ratio. D.L.E.

FOOD VALUE OF DAIRY PRODUCTS

568. **The Value of Milk in the Diet.** W. E. Krauss, Ohio Agr. Exp. Sta., Wooster, O. Ohio Bimonthly Bull. XXIII, No. 194, Sept.-Oct., 1938.

This is a popular discussion of the food value of milk and is suitable for a 12-minute radio talk. The story builds up to make the point that the ultimate goal for milk consumption should be a pint a day for adults and a quart a day for children. W.E.K.

ICE CREAM

569. **The Frozen Food Industry.** Ivan C. Miller, McGraw-Hill Pub. Co., New York, Ice Cream Trade J., *34*, 9, p. 31, Sept., 1938.

Ice cream manufacturers are watching the development of the frosted food industry. Today he is not an important factor in the distribution of frozen foods. There is every reason to expect that in the future an important portion of retail frozen food distribution will be through the channels of the ice cream manufacturers. W.H.M.

570. **Manufacture of Sherbets and Ices.** W. H. Martin, Kansas State College, Manhattan, Kans. Ice Cream Trade J., *34*, 9, p. 12, Sept., 1938.

This article discusses the problems involved in the manufacture of sherbets and ices. Information is presented on sugar content, stabilizer, color, flavor, use of milk products, overrun, and storage. Formulae for sherbets and ices are given. W.H.M.

571. Triple Scoops. Malcolm Parks. Ice Cream Trade J., *34,* 8, p. 13, Aug., 1938.

The use of three No. 30 scoops of ice cream or sherbet in cones and other ice cream dishes has been found by many ice cream manufacturers to be an effective means of increased volume of sales. Mr. Parks presents dealers' cost sheet to show the profit possibilities in this type of merchandising and also gives directions for the preparation and sale of the various items made with three scoops of ice cream. W.H.M.

572. Frozen Food. Paul C. Trimble. Ice Cream Trade J., *34,* 8, p. 8, August, 1938.

Ice cream manufacturers who are considering the possibility of distributing frozen foods will be interested in this article which describes the experience of the Southern Dairies in the frosted foods field in the southern states. W.H.M.

573. Stabilizers and Their Use in Ice Cream. L. M. Lampert, State Dept. of Agriculture, Sacramento, Calif. Ice Cream Trade J., *34,* 7, p. 19, July, 1938.

A definition and classification of stabilizers is given, together with a description of the properties of the various products used in the stabilization of ice cream. The author states that no one can object to their use, provided that they meet reasonable requirements for efficiency, wholesomeness and purity. W.H.M.

574. Increased Sanitation in the Dispensing of Ice Cream. F. W. Fabian, Michigan State College, East Lansing, Mich. Ice Cream Trade J., *34,* 6, p. 20, June, 1938.

Surveys made by Fabian and others of conditions which surround the sale of ice cream indicate the need for ice cream manufacturers to pay more attention to their product after it leaves the plant. He recommends schools of instruction for those serving ice cream. Measures which will reduce the disease hazard in connection with the sale of ice cream are as follows:

1. Require that all scoops or other implements used in dishing ice cream be kept in water flowing at such a rate so as practically to eliminate the possibility of reproduction and growth of bacteria.

2. Require that all the dishes, silverware, and glassware used in serving ice cream be properly washed. These principles hold for either hand or mechanical washing. Water at a temperature of 140° F. to which has been added one per cent of a good detergent is the lowest best practical temperature to use. After the dishes, glasses, and spoons are washed, they should be rinsed in water at a temperature of not less than 170° F.

3. A bacterial standard of 5000 per gram for flavoring syrups and fruits is suggested.

4. The dispenser should be free of contagious disease and should be clean and neat in his personal appearance.

5. The use of individual package goods should be encouraged by all those interested in producing and serving ice cream. This will do away with most of the objectionable sanitary features which one now observes at many serving places. W.H.M.

575. **The Influence of Temperature Upon the Extent to Which Freezing Occurs in Ice Cream.** W. C. COLE, Div. of Dairy Industry, Univ. of Calif., Davis, Calif. Ice Cream Trade J., *34*, 6, p. 15, June, 1938.

The amount of ice formed at different temperatures in ice cream, ice milk, and sherbets was measured by using a dilatometer. Known weights of the samples to be tested were admitted into the apparatus in such a manner that changes in volume of the sample could be determined. By taking into account the difference in volume before and after freezing at a given temperature and also considering the increase in volume accompanying the change of one gram of water to ice it was possible to calculate the amount of ice formed in the sample at that temperature. The authors summarize their results as follows:

1. Taking into account the changes in volume accompanying the crystallization of ice from solutions it has been possible to measure with a dilatometer the percentages of ice formed in ice cream and related products from 25° C. (13° F.), or slightly lower, to temperatures corresponding to the freezing points of the various samples studied.

2. The results obtained by this method show that at corresponding temperatures the percentages of water frozen in ice milk and ice cream are essentially the same for samples included in this study. Considerable variation occurred, however, in the percentages of ice in these samples depending upon the proportion of water they contained.

3. The results obtained for ices, varied considerably from those obtained for ice cream at corresponding temperatures, both as to the percentages of water frozen and the percentages of ice in the samples.

4. Presumably the data presented can be used as an indication of the extent to which freezing occurs in the commercial manufacture of ice cream and related products. W.H.M.

MILK

Abstracts of interest are 561, 568, 576 and 577.

MISCELLANEOUS

576. **Safety Improvement Thru Drivers Award System.** EDGAR G. QUESNEL, the Borden Company, Ice Cream Trade J., *34*, 9, 13, Sept., 1938.

The Borden Company has experienced a 25 per cent improvement in the safe operation of their vehicles during the past five years by using an award system for their drivers. The awards are usually lapel emblems, badges or certificates and sometimes cash. Accomplishments which may be expected by everyone participating in an Award System of this kind are always worthwhile. They result in good industrial and public relations, better transportation service, lower costs, better work, fewer interruptions, few accidents, less personal injury and property damage, minimum of public liability claims, and most important of all the conservation of the most valuable asset the company has—the life, happiness, ambitions and future accomplishments in the field of constructive service—the employee himself.

W.H.M.

577. **Cold Storage Lockers.** P. EDWIN THOMAS. Ice Cream Trade J., *34*, 7, p. 21, July, 1938.

"Practically unknown five years ago, some 2,000 cold storage locker businesses are reported in operation in almost half the States of the Union, with an investment of nearly $25,000,000." A floor plan for a 320 locker plant 35 feet wide by 70 feet long is illustrated. The cost of such a plant is estimated at $25 to $50 per locker and according to the figures presented, it would be possible for the plant to yield a return on investment of 10 per cent.

W.H.M.

578. **Index of Research Projects, Works Progress Administration.**

The results of some 2,000 research projects carried on as part of the federal work relief program are summarized briefly in a digest and index which has been published by the Works Progress Administration. This volume of 291 pages contains a concise statement of the principal conclusions of each study and an alphabetical subject index to the contents. The reports on these projects touch upon nearly every field of natural and social science and many of them have appeared in the form of articles in scholarly journals. However, several hundred of the reports summarized in this index are in manuscript form, and arrangements have been made with the American Documentation Institute whereby microfilm copies of the original reports will be furnished at nominal rates for the use of research specialists. A small edition of this volume has been prepared for distribution to the larger public and university libraries, where it will be available for reference, and for government departments, industrial concerns and research

foundations. A limited supply of copies of this Index of Research Projects are still available. Requests should be addressed to the Works Progress Administration in Washington. H.K.H.

PHYSIOLOGY

579. Concerning the Metabolism of Fat and Carbohydrate. Joseph L. Donnelly, Fort Thomas, Ky. Amer. J. Physiol. *124,* 1, p. 126, October, 1938.

From a selected group of data published by other workers, the author draws some very important inferences on the relation of total acidity of the body to fat and carbohydrate metabolism. He points out that as a general mode of behavior there is an increase in the size of the globules of fat in the tissues with any increase in the acidity of the animal. This increase in size of fat globules results in a loss of reactivity which parallels the decrease in dispersion of the fat. Moreover, the activity of lipase and bile is diminished by acid. After pointing out the apparent relationship between the concentration of sugar and fat in the blood, the author draws the conclusion that "the size of the tissue fat globule and the concentration of fat and carbohydrate in the blood vary directly while the utilization of fat and carbohydrate vary inversely with the total acidity of an animal."

The statement of Professor Denning (Research and Progress 4: 41. 1938) that soya bean meal induces alkalasis is of interest here. D.L.E.

580. The Effect of Pregnancy and Lactation on Growth in the Rat. H. H. Cole and G. H. Hart, College of Agriculture, University of California, Davis. Amer. J. Physiol. *123,* 3, p. 589, September, 1938.

The authors show that pregnancy stimulates skeletal and tissue growth in the rat beyond that found in non-bred littermate controls. The excess growth during pregnancy is accompanied by, and presumably dependent upon, an increased food consumption manifested by the second day after conception. It is postulated that the copulatory act brings about a nervous stimulation of the anterior pituitary, resulting in the secretion of one or more hormones involved in inducing an increased appetite.

The excess gains made by the pregnant rats remain fairly constant for the first six pregnancies, after which further pregnancies have less effect. The excess gains are made, for the most part, during pregnancy although rats suckling four to six young continue to gain as rapidly as non-bred controls. D.L.E.

581. The Ratio of Arterio-venous Differences of Certain Substances to Quantities Secreted by the Mammary Gland. J. C. Shaw and

W. E. PETERSEN, Department of Dairy Husbandry, University of Minnesota, Minneapolis, Minn. Proc. Amer. Physiol. Soc., Amer. J. Physiol. *123*, 1, p. 183, July, 1938.

Arterio-venous differences were determined on bloods drawn from the internal iliac and external pudic arteries and the subcutaneous abdominal milk veins for calcium, glucose, lactic acid, fat and amino acids.

The ratio of volume of blood flow traversing the gland to the amount of milk secreted was 1:387 when calculated from the blood calcium differences and the calcium in the milk. The ratio of the combined glucose and lactic acid differences to the lactose in the milk was 1:390 which is in good agreement with the calcium ratio. The differences in neutral fat indicated a ratio of 344 volumes of blood per volume of milk. The amount of amino acids removed by the gland are inadequate to account for more than 40 per cent of the proteins of the milk on this basis. The essential data follow.

	# of analyses	Arterial venous differences	Per cent in milk	Ratio
Amino-acid nitrogen	15	0.46 mgm. %	500 (total nit.)	1:1087
Glucose-lactic acid	17	12.44 "	4860 (Lactose)	1:391
Fat	39	11.63 "	4000	1:344
Calcium	20	0.31 "	120	1:387

D.L.E.

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JOURNAL
OF
DAIRY SCIENCE

VOLUME XXI

JANUARY, 1938, TO DECEMBER, 1938

1938
AMERICAN DAIRY SCIENCE ASSOCIATION
THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

THE SCIENCE PRESS PRINTING COMPANY
LANCASTER, PENNSYLVANIA

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JOURNAL OF DAIRY SCIENCE

OFFICIAL ORGAN OF
AMERICAN DAIRY SCIENCE ASSOCIATION

The Journal of Dairy Science is issued monthly. Subscription is by the volume and one volume is issued per year.

Manuscripts should be typewritten and carefully revised before submission to T. S. Sutton, The Ohio State University, Columbus, Ohio. Twenty-five reprints will be furnished gratis to authors. Cost of additional reprints and reprint order blank will be submitted with proof.

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Correspondence regarding business policies of the Journal should be addressed to the Secretary-treasurer, R. B. Stoltz, The Ohio State University, Columbus, Ohio.

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Any person is eligible to associate membership who is regularly enrolled in a collegiate course in a College of Agriculture and who is specializing in dairying. Associate membership is attained by election to membership in a local chapter of *The American Dairy Science Association.*

The dues are $5.00 a year for active membership. Correspondence regarding membership and dues should be addressed to R. B. Stoltz, Ohio State University, Columbus, Ohio.

periments on diastase were carried out with the use of a 15-minute incubation period and the flash method of pasteurization.

Other enzymes of vegetable and animal origin such as rennin, pepsin, papain, etc., were used with the same methods of pasteurization and results which were comparable but usually inferior were obtained.

The supernatant fluid obtained from mixing powdered pancreatic concentrate and water was found to have a slight curd softening effect but the decrease in curd tension was far less than that obtained when the dried particles of the pancreatic concentrate were included in the softening material. By allowing the powdered concentrate to soak in water for from one to two hours there was a slight increase in the amount of softening activity but this was found to be of only minor significance.

This method of producing soft curd milk has been tried out on a commercial scale using 100 gallon batches in a large dairy plant and has been found to be practical in all respects. The fat and acidity contents of the milks used were $3.6\% \pm 0.3\%$ and $0.16\% \pm 0.02\%$, respectively. Ammonium carbonate was dissolved in the water into which the pancreatin was mixed and it was found to have an inhibitory action on the curd softening enzymes. No other alkaline materials were used in an attempt to adjust the pH of the water.

Sixteen calves were used in a feeding test, each calf receiving four 1 gallon lots of milk during four feedings. The milk used in the third feeding was colored red and the milk used in the fourth feeding was colored blue so that when the calves were killed seven hours after the last feeding the amount of curd which remained in the stomach from each feeding could be determined. The calves which were fed normal pasteurized milk retained 23 per cent more curd in their stomachs than did the calves which were fed soft curd milk and the tension of the normal curds, as measured by the Hill Curdometer, was twice as great as the enzyme curds. Calves were used in this test because they were thought to be a natural testing medium for cow's milk, and because of the possibility of examining the stomach contents after slaughter.

The data incorporated in Table 2 show the relative value of P_2O_5, protein, calcium, magnesium and formol titration of the control milk in comparison with the enzymatically softened milk and zeolite softened milk. These milks were also dialyzed and the dialysate analyzed for P_2O_5, calcium and magnesium. The whey from the normal and enzyme treated samples was also analyzed for P_2O_5, calcium and magnesium. The P_2O_5 analyses show only small variations. This was found to be true also with the analysis for protein and the formol titration. The results of the magnesium determinations show that probably the only significant feature demonstrated is that the zeolite dialysate samples contained no magnesium. There was such a slight variation in the calcium values of the wheys and dialysates that here

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TABLE 2

*Calcium, magnesium, phosphorus, protein and formol titration values of normal, enzyme treated, and zeolite treated milk**

Sample	P_2O_5 %	Ca %	Mg %	Protein (Kjeldahl $N \times 6.25$) %	Formol titration (Walker) (10 cc. sample) cc. N/10 NaOH
Normal Control Milk A	.126	.190	.009	3.13	1.1
Normal Control Milk B	.167	.188	.008	3.07	1.2
Enzyme Softened Milk A	.150	.194	.007	3.02	1.3
Enzyme Softened Milk B	.149	.196	.007	3.00	1.5
Zeolite Milk I	.131	.157	.009	2.97	1.2
Zeolite Milk II	.133	.159	.009	2.72	1.3
Dialysate of Control Milk A	.036	.015	.006		
Dialysate of Control Milk B	.032	.021	.005		
Dialysate of Enzyme Softened Milk A	.038	.026	.004		
Dialysate of Enzyme Softened Milk B	.031	.023	.003		
Dialysate of Zeolite Softened Milk I	.033	.032	.000		
Dialysate of Zeolite Softened Milk II	.038	.043	.000		
Whey of Control Milk A (rennet coagulation)	.088	.070	.007		
Whey of Control Milk B (rennet coagulation)	.087	.065	.005		
Whey of Enzyme Softened Milk A	.089	.075	.009		
Whey of Enzyme Softened Milk B	.090	0.85	.005		

* All samples in duplicate. All "A" and "B" samples represent split batches of the same milk.

too no outstanding significance is demonstrated. The calcium values of the zeolite softened milk samples were found to contain 18 per cent less calcium than the control samples and the enzyme treated samples.

Clinical investigations on a milk prepared by this method are being carried out.

CONCLUSIONS

The curd tension of ordinary cow's milk may be softened by pancreatic concentrate to within a range of 20 to 30 grams and the curd tension of samples of milk which have been softened enzymatically decrease in their curd tension value upon storage.

Either the flash or holder type of pasteurization may be employed in the method described above.

Calves fed milk which has been softened with pancreatic concentrate retain the curd in their stomachs for a shorter period of time and the curd formed therein is much softer than the curd formed when normal pasteurized milk is fed.

The P_2O_5, calcium, magnesium, protein and formol titration values are changed so slightly from that of pasteurized milk that they are of little significance in studying the nature of enzymatically softened milk.

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THE CHEMICAL COMPOSITION AND PROPERTIES OF NORMAL AND RANCID JERSEY MILK

III. TITRATABLE ACIDITY, HYDROGEN-ION CONCENTRATION AND LIPASE CONTENT

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A study has been made of the chemical composition of the milk of a Jersey herd in relation to the off-flavor, rancidity. In the course of the study normal values were established for several constituents of milk, both for individuals and for the herd throughout the entire lactation period. The composition of rancid milk has been compared with that of normal milk of the same individual and of the herd. The chloride, lactose, fat, total solids and protein content of the milk has been reported in previous papers (3) (4). The present paper discusses the titratable acidity, hydrogen-ion concentration and lipase content of normal and rancid milk.

Published data indicate a wide range in the titratable acidity and pH of normal milk. This variation is attributed to such factors as breed, environment, period of lactation, and individuality. In the present study the number of variable factors was reduced by employing a single breed of cows, by maintaining them under the same environmental conditions and by comparing the composition of rancid milk with that of normal milk produced in the same period of lactation.

EXPERIMENTAL

Management of animals and methods of obtaining milk samples have been described in a previous paper (3). Over a period of eight months, determinations were made of the titratable acidity and pH values of samples taken weekly from each of 18 members of the Jersey herd. Lipase determinations were made over a period of 20 months.

Titratable acidity was determined by titrating 10 cc. of the fresh sample with 0.1 N NaOH, using phenolphthalein as an indicator. The degree of acidity of the sample is expressed as the percentage of lactic acid. pH was determined by use of the quinhydrone electrode. Methods used in estimation of the lipolytic activity of milk are discussed later.

PRESENTATION OF DATA

Titratable Acidity and Hydrogen-Ion Concentration of Normal Jersey Milk

The mean titratable acidity and pH values of all milk samples obtained from each of 12 animals are shown in Table 1. The mean acidities ranged

Received for publication February 1, 1938.

from 0.158 per cent to 0.112 per cent; individual samples showed minimal and maximal values of 0.122 per cent and 0.410 per cent, respectively. The mean pH values ranged from 6.60 to 6.43, with minimal and maximal values of 6.56 and 6.10 for individual samples.

Monthly changes in the mean titratable acidity and pH values of the normal milk of the herd are shown in graphs 1 and 2, Figure 1. The general

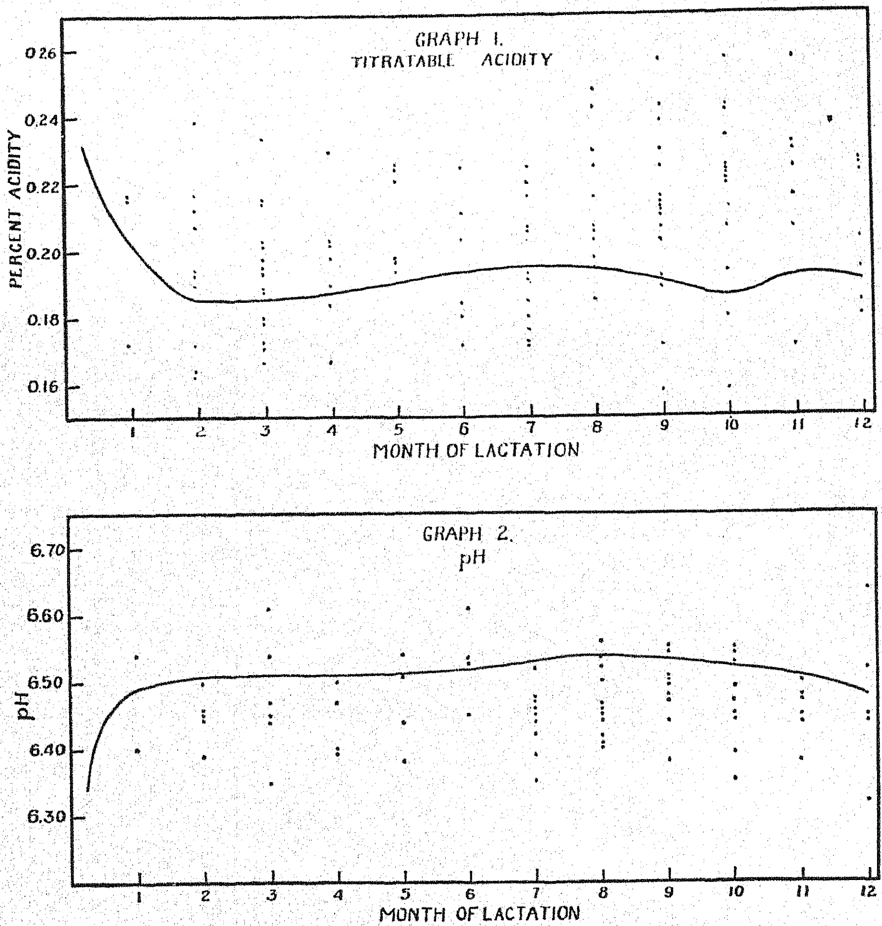

FIG. 1. Titratable acidity and pH of normal and … milk.

Graph 1

—— Mean titratable acidity of all normal samples fo… month of the lactation period.

● Titratable acidity of rancid samples.

Graph 2

—— Mean pH of all normal samples for each m… of the lactation period.

● pH of rancid samples.

trends of titratable acidity and hydrogen-ion concentration throughout lactation were similar, both showing a rapid decrease at the beginning of lactation, with little change thereafter. During the first six weeks the mean titratable acidity dropped from 0.234 per cent to 0.185 per cent, and the pH increased from 6.34 to 6.53, after which they remained nearly constant until the end of lactation.

The above data are summarized in Table 2, which shows the mean titratable acidity, hydrogen-ion concentration and pH of all normal samples for each of twelve four-week periods.The coefficients of variation indicate a marked variation in milk from different animals in the same period of lactation. The mean titratable acidity of 357 normal samples was 0.189 ± 0.004 per cent with a standard deviation of ± 0.027, and a coefficient of variation of 20.6; the mean hydrogen-ion concentration was $3.05 \pm 0.04 \times 10^{-7}$ (pH 6.52) with a standard deviation of ± 0.63 and a coefficient of variation of 14.2.

Caulfield and Riddell (1) have reported values for the titratable acidity of the milk of six Jersey cows as determined by samples collected at monthly intervals throughout a complete lactation. Their values are in close agreement with those reported here. They found an average titratable acidity of 0.179 per cent, individual variation in average acidities of from 0.098 per cent to 0.295 per cent, and a range of from 0.194 per cent in the first month to 0.145 per cent in the tenth month of lactation. They also observed a marked drop in titratable acidity between the first and second months of lactation, after which the acidity remained nearly constant through the seventh month. During the last month of lactation they found a marked decline in the average acidity of milk. Such a decline was not observed in the present study; instead, a slight increase in titratable acidity manifested itself in the milk of animals whose lactation period was unduly prolonged.

The fairly wide deviation in the pH of milk is well recognized. Sommer (5) in a recent study observed a range of from 6.77 to 6.22 in the pH values of 386 milk samples obtained from 43 cows (breed not specified). 140 of the samples had pH values of from 6.36 to 6.45 and 144 from 6.46 to 6.55. These values are in agreement with those observed in the present study.

Titratable Acidity and Hydrogen-Ion Concentration of Rancid Jersey Milk

As may be seen in Table 1, five animals produced no rancid milk during the period in which titratable acidity and pH were determined. The mean titratable acidity of their milk varied from 0.158 per cent to 0.203 per cent, with an average value of 0.185 per cent; the pH values ranged from 6.60 to 6.47, with an average of 6.54. Seven animals produced rancid milk comprising 19 to 100 per cent of all samples obtained from them. The mean titratable acidity of their milk ranged from 0.162 per cent to 0.212 per cent and averaged 0.194 per cent; the pH values varied from 6.53 to 6.43, with

determinations were made of the degree of hydrolysis produced by decreasing amounts of a commercial preparation of lipase during a one hour's incubation period. In the first series of experiments an aqueous medium was employed. The addition of 240, 160, 100, 80, 60 and 40 mgs. of the lipase preparation produced amounts of acid equivalent to 18.0, 15.0, 10.0, 8.0, 6.5 and 4 ml. of 0.1 N NaOh, respectively; the lipolytic activity of amounts less than 20 mgs. is shown by curve 1, Figure 2.

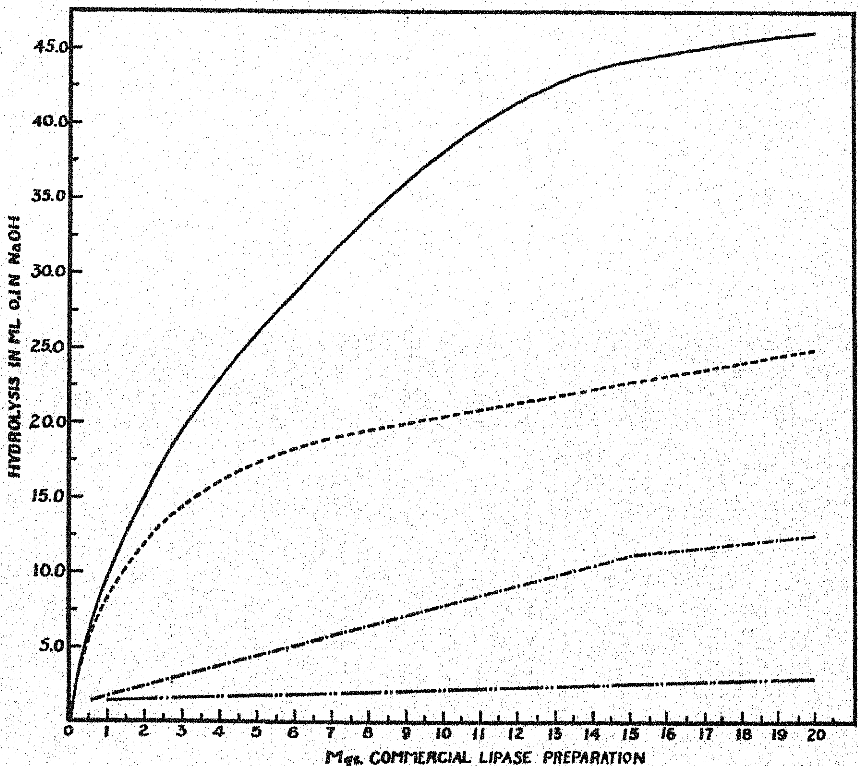

FIG. 2. Hydrolysis of olive oil and tributyrin by commercial lipase preparation in media of milk and water.

·——· Aqueous medium, olive oil substrate, 1 hour incubation.
·—·—· Milk medium, olive oil substrate, 1 hour incubation.
----- Milk medium, olive oil substrate, 24 hours incubation.
——— Milk medium, tributyrin substrate, 24 hours incubation.

In the second series of experiments, inactivated milk served as the medium. Inactivation was effected by heating the milk for one hour at 70° C. Curve 2, Figure 2, shows the degree of hydrolysis produced in one hour by amounts of lipase preparation ranging from 20 mgs. to 0.6 mgs.

The emulsion of milk and olive oil proved to be more favorable to the action of lipase than the emulsion of water and olive oil. By increasing the

period of incubation from one to 24 hours, it was possible, using milk as a dilutant, to detect the presence of 0.06 mg. lipase preparation, as may be seen from curve 3, Figure 2. A 24-hour incubation period was therefore adopted.

In a second method later employed for the estimation of lipase, two 50 ml. aliquots of each milk sample were used, one aliquot serving as a control. The control was heated for one hour at 70° C. to inactivate the lipase present. To each of the aliquots were added 50 ml. water, 0.5 ml. tributyrin and 4 drops of formaldehyde. The two reaction mixtures were then shaken for three minutes and incubated for 24 hours at 30° C., after which they were diluted and titrated as described above. The difference between the titration values of the raw and inactivated samples after incubation was taken as a measure of the degree of hydrolysis produced.

To determine the smallest amount of lipase which could be detected by this method, known amounts of lipase preparation were added to previously inactivated milk. Lipase added to the controls was also inactivated. Results obtained by this method are given in Curve 4, Figure 2. This method proved as sensitive as the first method for amounts of the lipase preparation less than 1 mg. and more sensitive for amounts greater than 1 mg.

RESULTS

The two methods described above were used in estimating the lipase content of 490 samples of milk, 121 of which were rancid. The results are given in Table 4. In this table samples are grouped according to flavor and without regard to the period of lactation, since there appeared to be no correlation between the period of lactation and the amount of lipase present. Table 4 also includes the amount of commercial lipase preparation which under the same conditions produced a corresponding degree of hydrolysis. These amounts were read from curves 3 and 4, Figure 2, when methods 1 and 2 respectively, were employed.

The results indicate that all samples had a definite lipolytic action which was, however, very small when compared with a commercial lipase preparation. As determined by the first method, 10 ml. of normal milk produced the same degree of hydrolysis as did approximately 0.15 mgs. of the lipase preparation; when the second method was employed 50 ml. of normal milk showed a lipolytic activity equivalent to that of 0.4 mg. of lipase preparation.

By both methods, samples described as "very slightly" or "doubtfully" rancid were found to have a lipolytic activity approximately equal to or somewhat less than that of normal milk; "slightly" rancid samples produced a somewhat greater amount of acid than did normal milk, differences in the average titrations being 0.8 mg. and 0.9 mg. for the two methods. Twenty-seven "very rancid" and "rancid" samples analyzed by the first procedure showed about twice as much lipolytic activity as normal milk. One "very

TABLE 1

Titratable acidity and pH values of normal and rancid milk of 12 Jersey cows

Cow number	Milk samples		Mean titratable[1] acidity			Mean pH		
	Normal	Rancid	Normal	Rancid	Total	Normal	Rancid	Total
	number	*number*						
1	20	0	0.176	......	0.176	6.55	......	6.55
2	35	0	0.158	......	0.158	6.60	......	6.60
3	29	0	0.203	......	0.203	6.51	......	6.51
4	18	0	0.189	......	0.189	6.56	......	6.56
5	27	0	0.203	......	0.203	6.47	......	6.47
6	21	4	0.198	0.275	0.198	6.52	6.33	6.47
7	24	4	0.203	0.203	0.203	6.51	6.47	6.51
8	15	7	0.176	0.185	0.180	6.49	6.53	6.50
9	22	9	0.212	0.216	0.212	6.46	6.35	6.43
10	9	17	0.162	0.167	0.162	6.57	6.46	6.53
11	14	18	0.194	0.225	0.212	6.47	6.47	6.47
12	0	30	......	0.203	0.203	......	6.48	6.48

[1] Expressed as percent lactic acid.

TABLE 2

Titratable acidity and hydrogen-ion concentration of normal[1] Jersey milk in relation to the period of lactation

Lactation periods	Milk samples	Titratable acidity[2]			Hydrogen-ion concentration ($\times 10^{-7}$)			pH[6]
		Mean	S. D.[3]	C. V.[4]	Mean	S. D.[3]	C. V.[4]	
weeks	*number*			*percent*			*percent*	
1–4	40	0.203 ± 0.005[5]	0.035	17.3	3.68 ± 0.13[5]	0.84	22.8	6.43
5–8	48	0.185 ± 0.004	0.024	12.9	3.05 ± 0.08	0.54	17.6	6.51
9–12	27	0.185 ± 0.005	0.022	11.7	3.07 ± 0.07	0.49	16.0	6.51
13–16	36	0.194 ± 0.005	0.030	15.0	2.96 ± 0.05	0.35	12.0	6.53
17–20	32	0.185 ± 0.005	0.029	15.7	3.01 ± 0.11	0.74	24.5	6.52
21–24	30	0.194 ± 0.005	0.031	15.6	3.10 ± 0.09	0.57	18.3	6.51
25–28	22	0.194 ± 0.005	0.022	11.1	2.92 ± 0.06	0.42	14.5	6.53
29–32	26	0.194 ± 0.006	0.029	11.1	2.89 ± 0.06	0.41	14.3	6.54
33–36	28	0.185 ± 0.005	0.023	15.0	2.74 ± 0.07	0.45	16.4	6.56
37–40	14	0.180 ± 0.006	0.023	12.7	3.07 ± 0.08	0.55	17.9	6.51
41–44	10	0.194 ± 0.005	0.024	12.8	3.01 ± 0.07	0.45	15.2	6.52
45–48	13	0.185 ± 0.006	0.023	11.7	3.29 ± 0.18	1.19	36.0	6.48

[1] No rancid samples are included.
[2] Expressed as percent lactic acid.
[3] Standard deviation of mean.
[4] Coefficient of variation of mean.
[5] Standard error of mean.
[6] Corresponding to the mean hydrogen-ion concentration for the period.

rancid'' sample analyzed by the second method produced approximately ten times as much acid as did normal milk. This was, however, the only sample to display such a marked degree of activity.

One would conclude, therefore, that all milk contains lipolytically active

TABLE 3

Titratable acidity and hydrogen-ion concentration of normal and rancid Jersey milk

Description of samples	Milk samples	Titratable acidity[1]		Hydrogen-ion concentration ($\times 10^{-7}$)			pH[4]
		Mean	Standard deviation	Milk samples	Mean	Standard deviation	
	number			*number*			
Very rancid, rancid and slightly rancid	84	0.212 ± 0.005[2]	0.035	56	3.89 ± 0.17	1.30	6.41
Very slightly and doubtfully[3] rancid	47	0.194 ± 0.004	0.023	21	3.20 ± 0.09	0.48	6.49
All rancid samples	131	0.203 ± 0.003	0.033	77	3.68 ± 0.09	1.17	6.43
Normal	357	0.189 ± 0.002	0.027	211	3.05 ± 0.04	0.63	6.51

[1] Expressed as percent lactic acid.
[2] Standard error of mean.
[3] Samples criticized as rancid by less than half the judges.
[4] Corresponding to the mean hydrogen-ion concentration.

TABLE 4

The lipolytic activity[1] of normal and rancid Jersey milk

Description of samples	Method 1. (10 ml. milk)			Method 2. (50 ml. milk)		
	Milk samples	Hydrolysis in ml. 0.1 N NaOH	Commercial lipase equivalent[2]	Milk samples	Hydrolysis in ml. 0.1 N NaOH	Commercial lipase equivalent[2]
	number		*mg.*	*number*		*mg.*
Very rancid	1	4.2	0.40	1	43.6	14.6
Rancid	26	2.8	0.25	3	9.7	1.0
Slightly rancid	32	2.3	0.20	25	5.4	0.5
Very slightly rancid	10	1.5	0.15	9	3.9	0.4
Doubtfully[3] rancid	13	0.9	0.10	5	3.8	0.4
Normal	159	1.5	0.15	210	4.5	0.4

[1] Expressed in terms of ml. 0.1 N NaOH required to neutralize the free fatty acids produced during a 24-hour incubation period.

[2] Amount of commercial lipase preparation producing a degree of hydrolysis equal to that produced by milk samples under the same conditions.

[3] Samples criticized as rancid by less than half the judges.

substance and that milk which has a definitely rancid flavor is somewhat more active lipolytically than is normal milk.

SUMMARY AND CONCLUSIONS

Data have been presented showing the titratable acidity, hydrogen-ion concentration and lipase content of the milk of animals of a Jersey herd, all of which received the same ration and were subject to the same environmental conditions. The amounts found in milk criticized as rancid have been compared with those present in normal milk of the same period of lactation.

Rancid milk was found usually to have a higher titratable acidity and hydrogen-ion concentration than normal milk of the same period of lactation. The mean titratable acidity and hydrogen-ion concentration of all rancid samples were significantly higher than the mean values for all normal samples.

All milk was found to contain a small amount of lipolytically active substance. Definitely rancid milk was somewhat more active lipolytically than was normal milk.

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A COMPARATIVE STUDY OF METHODS OF DETERMINING THE MOISTURE CONTENT OF CHEDDAR CHEESE

II. THE STEAM OVEN METHOD AT HIGH PRESSURE AND THE OLIVE OIL METHODS*

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INTRODUCTION

In a previous study (1) a discussion of the use of an open flame-olive oil method for the determination of moisture in Cheddar cheese was given and its accuracy compared with the Mojonnier method, slightly modified. In addition, a modification of the oil method was suggested in which a small amount of sodium chloride was added to the oil. The addition of the salt prevented the cheese from lumping and sticking during heating, and also prevented the cheese from spattering. The olive oil method gave results approximately 0.3 per cent above those secured by the Mojonnier method, whereas the oil method, modified by the addition of salt, gave results averaging approximately 0.55 per cent higher than the results by the Mojonnier procedure.

The steam pressure oven method for moisture determination was originally developed for butter (2), but has since been more widely adopted for cheese analysis. Sammis (3) (4) gives in detail the steps involved in the moisture determination of cheese by this method, and points out that a 10 gram sample is dried satisfactorily in at least 4 to 5 hours and a 5 gram sample in about one-half of this time when the steam pressure ranged from 50 to 60 pounds. According to this author, excessive heating periods in the steam pressure oven had little effect on new cheese, but old cured cheese continued to lose weight at a noticeable rate. Van Slyke and Price (5) point out that disastrous effects on the samples may occur if the oven is connected directly with a boiler carrying a high steam pressure without having an intervening valve. Sammis (3) in discussing the steam pressure oven method, states that "duplicates commonly agree with each other within 0.5 per cent."

In connection with the study of the olive oil method previously reported (1), samples of Cheddar cheese which were analyzed for moisture by the oil procedure were also dried to constant weight by the use of a steam pressure oven. It was thought desirable to tabulate the data collected and to compare the results obtained by these methods.

Received for publication February 7, 1938.

* Authorized as Mich. Agric. Exp. Sta. Jour. Article No. 308 (n. s.).

EXPERIMENTAL

The cheese was prepared and kept for analysis according to directions previously outlined (1). The moisture analysis by use of the steam pressure oven was made on a 2–3 gram sample which was weighed in an aluminum dish approximately 55 mm. in diameter, 22 mm. in height, and provided with a slip-in inverted cover fitting tightly on the inside. The drying was carried out in a Farrington steam pressure oven connected directly to the main line which carried a steam pressure of approximately 85 pounds. Two and one-half hours were usually required to bring the samples to constant weight.

Analysis of the cheese by the olive oil method was carried out (a) by use of a 5 gram sample of finely chopped cheese in 20 cc. of olive oil; and (b) by use of 5 grams of cheese in 20 cc. of olive oil which contained approximately 1 gram of sodium chloride. The latter procedure will be referred to as the modified olive oil method. More detailed information concerning the procedure for the oil methods has been given (1).

Differences between Duplicates: Excellent checks between duplicate determinations were obtained by the steam oven method. The average difference between duplicates of 29 trials by this method was 0.19 ± .02 per cent with 18 or approximately 62 per cent of the duplicates varying 0.2 per cent or less. Only one of the 29 trials showed variation between duplicates greater than 0.5 per cent. The variations one might expect by the use of the olive oil method were discussed previously (1) in which it was found that in 28 trials, the average difference between duplicates by the regular oil method was found to be 0.26 ± .03 per cent. Sixty-four per cent of these duplicates varied not greater than 0.2 per cent. In the case of the modified olive oil method, 63 per cent of the duplicates gave variations which fell within this range, with the average difference of 20 trials being 0.20 ± .03 per cent.

Comparison of Results: The results of the analysis of Cheddar cheese by the steam pressure oven method, by the olive oil method, and by the modified olive oil method are given in Table 1.

The results show the steam pressure oven method, at the high pressure operated, gave results averaging approximately 0.3 per cent above those secured by the regular olive oil method. The average of the individual differences for the 31 trials was somewhat greater, averaging 0.49 ± .04 per cent. That the oven method tends to give higher results is shown by the fact that 28 of the 31 trials gave higher values by the steam oven method than by the regular olive oil procedure.

The modified olive oil method gave results which for 17 trials averaged within 0.1 per cent of the steam oven method. The averages of the differences between the results for the individual trials was 0.31 ± .04 per cent. Ten of the moisture analyses were lower by the modified oil method, whereas

TABLE 1

The moisture content of Cheddar cheese when determined by the steam oven method at 85 pounds pressure, by the olive oil method, and by the modified olive oil method

Sample	Steam Pressure Oven Method	Olive oil method		Modified oil method	
No.	Moisture	Moisture	Difference from steam oven	Moisture	Difference from steam oven
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	37.75	36.60	−1.15	....	....
2	35.53	34.90	−0.63	....	....
3	34.52	34.31	−0.21	....	....
4	34.69	33.85	−0.84	....	....
5	34.53	34.14	−0.39	....	....
6	34.48	33.75	−0.73	....	....
7	34.85	34.03	−0.82	....	....
8	36.63	35.72	−0.91	....	....
9	30.69	29.99	−0.70	....	....
10	33.92	33.87	−0.05	....	....
11	31.73	30.29	−1.44	....	....
12	32.49	31.73	−0.76	....	....
13	44.62	44.02	−0.60	....	....
14	44.24	44.05	−0.19	....	....
15	44.08	43.50	−0.58	....	....
16	42.82	42.76	−0.06	....	....
17	41.94	41.96	+0.02	....	....
18	43.81	43.77	−0.04	....	....
19	38.86	38.71	−0.15	....	....
20*	38.34	....	....	38.07	−0.03
21	36.95	36.43	−0.52	36.76	−0.19
22	37.02	36.75	−0.27	37.17	+0.15
23	33.78	32.78	−1.00	33.10	−0.68
24	33.83	33.54	−0.29	33.12	−0.71
25	34.44	34.02	−0.42	34.48	+0.04
26	37.54	37.28	−0.26	37.45	−0.09
27*	38.80	....	....	38.89	+0.09
28	40.86	40.28	−0.58	40.84	+0.04
29*	40.75	....	....	40.60	−0.15
30	35.10	34.76	−0.34	34.83	−0.27
31*	34.57	....	....	34.85	+0.28
32	36.37	36.46	+0.09	....	....
33	39.52	40.24	+0.72	39.89	+0.37
34	35.41	35.23	−0.18	34.84	−0.57
35*	39.89	....	....	39.61	−0.28
36*	40.95	....	....	41.91	+0.96
37	39.94	39.75	−0.19	39.77	−0.17
Average, 31 trials	37.19 ± .47	36.75 ± .49	0.49 ± .04**	....	....
Average, 17 trials	37.51 ± .41	....	....	37.42 ± .45	0.31 ± .04**

* Samples spattered when attempts were made to analyze them by the regular olive oil procedure.

** Signs neglected in computing average.

7 were higher. As was observed in the previous paper, certain samples analyzed by the modified olive oil method could not be analyzed by the regular oil procedure due to spattering during heating which threw a portion of the material from the dish.

SUMMARY

A comparison was made between the steam oven method operating at approximately 85 pounds pressure; the regular olive oil method, in which 5 grams of cheese are placed in olive oil and heated to dryness directly over a small gas flame; and the modified olive oil in which sodium chloride is added to the cheese-olive oil mixture to prevent spattering and sticking of the cheese. The results showed the olive oil method to give values averaging approximately 0.35 per cent lower than the oven method, whereas the salt-olive oil procedure gave results which averaged within 0.1 per cent of those secured by the steam oven.

Either of these oil methods appear to give results which, on the basis of these comparisons with the steam pressure oven method, would be accurate enough for all practical purposes. Further, the oil methods have the distinct advantage of requiring less time than the oven procedure, since the test may be completed within 20 to 30 minutes, especially when the modified procedure is followed.

The modified oil method has greater applicability than the regular olive oil method since (a) it permits more rapid heating and drying due to the fact that the particles of cheese do not lump together, (b) it prevents the cheese from sticking to the bottom of the pan during the heating process, and (c) it has permitted practically all of the Cheddar cheese samples thus far encountered to be analyzed without experiencing the difficulty with spattering which occurs frequently with the regular oil method. However, during some recent trials, two samples of cheese did not lend themselves to moisture determination by the modified oil method because of spattering. Both of these samples were abnormally high in moisture which may account for their behavior.

Although this and the previous paper have dealt with the use of olive oil in the open flame test, other oils with higher volatilization points may be superior to the olive oil for this method of moisture analysis. It was observed in the trials reported that some volatilization of the olive oil did occur during heating, resulting in the formation of a disagreeable odor. This slight volatilization, however, did not appear to have any appreciable influence on the moisture results. Several trials have since been carried out using cottonseed oil, and indications are that this oil may be superior to olive oil for the moisture test. It has a higher volatilization point and is considerably less expensive. Mineral oil is less satisfactory since it requires a relatively low temperature for volatilization.

ACKNOWLEDGMENT

The author expresses his appreciation to Mr. F. J. Gregarek, now of the Detroit health department, for his aid in carrying out a portion of the analyses presented in this paper.

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THE KEEPING QUALITY OF BUTTERS

I. THE RATES OF DETERIORATION OF BUTTERS MADE FROM CREAMS OF DIFFERENT ACIDITIES AND STORED AT VARIOUS TEMPERATURES*

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The question of the effect of the acidity of cream upon the keeping quality of its butter has been the subject of numerous discussions and investigations. While it is generally agreed that butter made from sweet cream keeps better in storage than butter made from acid cream, there seems to be some differences of opinion on this subject when dealing with a product made from cream known as "low-acid cream." Furthermore, all acid cream butters do not exhibit the same rate of deterioration in storage, but vary in this respect with the degree of acidity of the cream from which they were prepared.

In reports of the Iowa Experiment Station (1) (2) (1890 and 1892) work is reported which showed that butter made from sweet cream kept better than did butter made from sour cream. In each instance raw cream was used. Studies begun in 1905 by the U. S. Department of Agriculture (3) (4) (5) of the influence of the acidity of cream upon the keeping quality of butter, established the fact that butter made from unripened pasteurized sweet cream maintained its fine quality to a high degree during at least 8 months of storage at 0° C.

The deterioration of butters made from creams of different acidities was studied by White, Trimble and Wilson (6), who found that butters made from creams with acidities of from 0.15 per cent to 0.31 per cent kept well in storage at 0° F. for 8 months. After 12 months at 0° F. butters from creams of from 0.15 to 0.25 per cent acidity had deteriorated less than those made from creams of 0.28 to 0.31 per cent acidity, and the latter had deteriorated less than those made from creams of higher acidities. They found also that ripening cream with a lactic culture, even to relatively low acidities improved the score of the fresh butter therefrom, but the improvement was usually lost in storage. The deterioration was judged entirely by loss of score. The results upon the butters from cultured cream confirmed the conclusions of Mortensen (1922) (7) that ripened cream butter received a higher commercial score than did sweet cream butter when fresh but that sweet cream butter kept better in storage. This author states further (1936) (8):

"Research on cream ripening was continued for several years and we recommend at present that the acidity shall not exceed .36 per cent in the

Received for publication February 10, 1938.

* Presented at the meetings of the American Butter Institute, Chicago, Ill., Nov. 30–Dec. 1, 1937.

serum. That represents an acidity in a 30 per cent cream of .70 × .36 or .25 per cent. Whether this figure will be changed somewhat in the future will depend on the research of the next few years; it is my belief that it is about right. By applying the proper system of ripening, this degree of acidity will produce flavor and keeping qualities superior to those of sweet cream butter."

In order to determine accurately the relative keeping quality of butters from creams of different acidities their rates of deterioration over a relatively long storage period must be known. This is especially true of butters made from low acid creams whose rates of deterioration are slow in the initial periods of storage and accelerate with increased time of storage. In the present work, therefore, samples of each butter were, except in a few cases, scored and tested at regular intervals until the respective butter was declared unfit for consumption.

Though "score" has proved invaluable as an index of the quality of butter it is not especially valuable as a test by which chemical changes of butter may be detected or followed with accuracy. It is rather an opinion of quality based upon a number of factors and has no definite meaning except as it relates to edibility of the product. In the present work the "score" has been supplemented with chemical tests which have proved of value in the study of the deterioration of fats and oils. These tests have furnished data of a quantitative nature by means of which the rate of deterioration through oxidation changes have been accurately expressed and the relative value of the score method and other methods determined. The data obtained furnished also some information upon one of the major problems under consideration; namely, a method which would indicate early in the storage period the susceptibility of butterfat to chemical change and could therefore be used to predict keeping quality.

EXPERIMENTAL

Fresh creams of 0.12 to 0.14 per cent acidity were pasteurized and churned to furnish the control samples of butter. Other samples were pasteurized, brought to an acidity of approximately 0.20 per cent, others to acidities of approximately 0.30 and 0.40 per cent, respectively, and then churned. The butters from each churning were divided into five lots and samples of these were stored at each of five different temperatures. The chosen temperatures of storage were 20° C., 10° C., 0° C., – 10° C., and – 17° C., respectively. The samples stored at – 17° C. were tested and scored at 90-day intervals, those at – 10° C. at 80-day intervals, etc., as indicated in Table I.

The tests chosen to indicate the rate of deterioration were score, peroxide value, time of bleaching at 42° C., and two dye reduction tests. The last four of these tests are definitely related to oxidation, a reaction which our studies on fats and oils have led us to believe is directly and indirectly an underlying cause for many of the off flavors of butter. Because of many

TABLE 1

The averages of values obtained in the different tests, upon butters stored for varying periods of time at different temperatures

Average acidity of cream (% lactic)	Number of samples	Days in storage	Peroxide value (M. mols per k)	Bleaching time at 42° C. (Days)	Average score	Days in storage	Peroxide value (M. mols per k)	Bleaching time at 42° C. (Days)	Average score	Days in storage	Peroxide value (M. mols per k)	Bleaching time at 42° C. (Days)	Average score	Days in storage	Peroxide value (M. mols per k)	Bleaching time at 42° C. (Days)	Average score	Days in storage	Peroxide value (M. mols per k)	Bleaching time at 42° C. (Days)	Average score
Storage at 20° C.																					
.13	5	0	0	88	91.7	20	0.18	......	89.6	52	0.88	66	88.7								
.19	8	0	0	86	91.7	20	.09	......	89.8	52	.73	71	89.0								
.31	5	0	0	88	92.0	20	.62	......	89.0	52	1.62	31	88.2								
.41	4	0	0	70	91.25	20	1.25	......	86.6	52	7.41	13	86.3								
Storage at 10° C.																					
.13	5	0	0	88	91.7	35	0.28	90	91.1	72	0.63	79	90.0	108	1.26	46	89.1				
.19	8	0	0	86	91.7	35	.19	102	89.8	72	.61	71	89.7	108	1.21	51	89.4				
.31	5	0	0	88	92.0	35	1.13	56	88.8	72	1.22	50	88.8	180	1.80	37	88.0				
.41	4	0	0	70	91.25	35	1.96	30	86.9	72	2.92	20	86.5	108	6.44	18	86.3				
Storage at 0° C.																					
.13	5	0	0	88	91.7	70	0.23	84	91.5	140	0.41	68	88.9	210	1.25	48	88.9				
.19	8	0	0	86	91.7	70	.17	106	92.0	140	.70	69	89.6	210	1.12	48	88.4				
.31	5	0	0	88	92.0	70	.74	74	90.8	140	1.32	60	87.4	210	1.53	38	87.9				
.41	4	0	0	70	91.25	70	1.44	44	88.6	140	3.39	38	87.0	210	4.69	19	86.4				
Storage at – 10° C.																					
.13	5	0	0	88	91.7	81	0.00	77	92.0	160	0.15	70	91.0	240	0.91	51	90.0	320	1.44	63	89.1
.19	8	0	0	86	91.7	81	.08	76	91.5	160	.54	58	90.6	240	.96	60	89.6	320	1.29	58	88.7
.31	5	0	0	88	92.0	81	.17	81	91.4	160	1.05	51	90.0	240	1.61	41	88.1	....	....	......	....
.41	4	0	0	70	91.25	81	.93	43	89.4	160	1.84	44	90.4	240	2.10	21	87.2	....	....	......	....
Storage at – 17° C.																					
.13	5	0	0	88	91.7	90	0.00	92	91.7	180	0.00	59	90.9	270	0.87	69	88.7	360	0.91	56	88.3
.19	8	0	0	86	91.7	90	.00	97	91.6	180	.22	65	90.8	270	.88	73	89.1	360	.96	......	88.6
.31	5	0	0	88	92.0	90	.17	55	90.9	180	.53	55	90.2	270	1.06	66	88.4	360	1.30	49	88.0
.41	4	0	0	70	91.25	90	.68	39	88.9	180	1.58	39	89.4	270	1.70	38	87.4	360	1.88	36	87.0

difficulties encountered in the application of the dye reduction tests, the data relating to this phase of the work will not be presented here.

In order to obtain a true value for the rate of deterioration and one that would be comparable for the different butters, especially for those held at

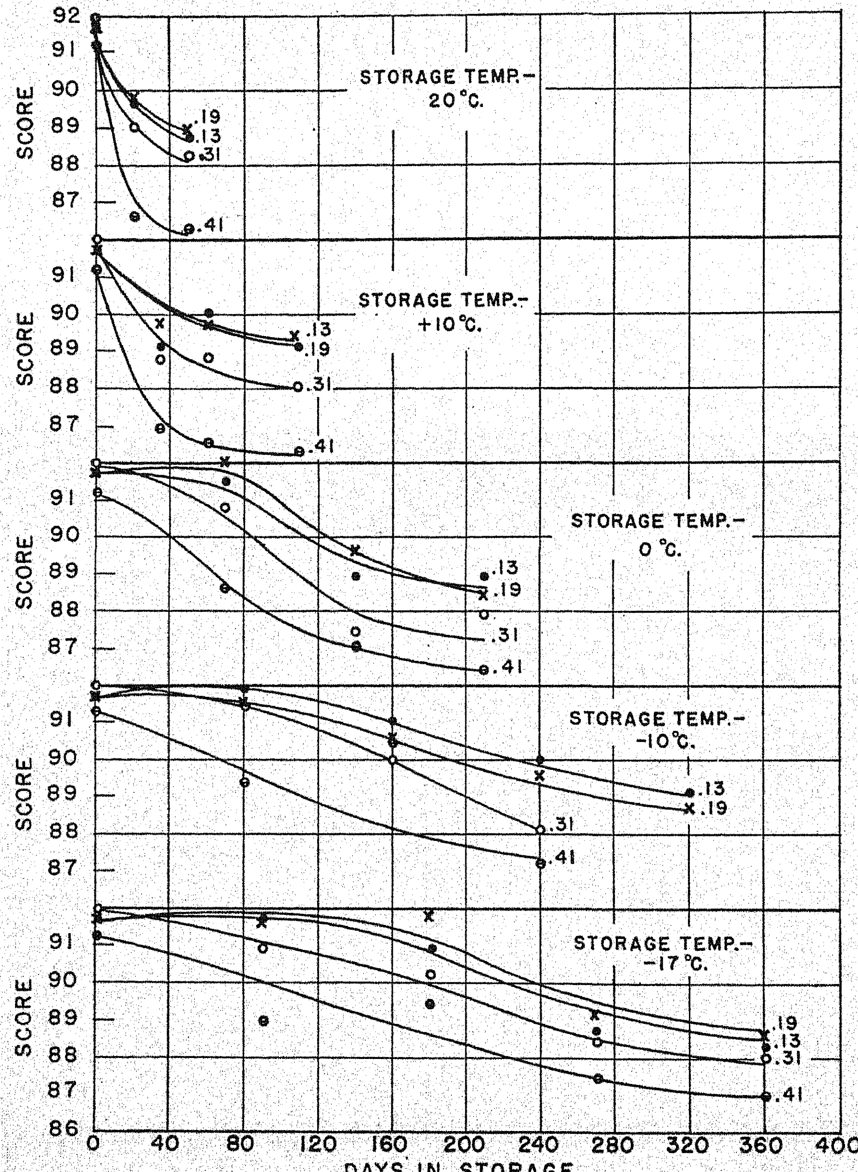

FIG. 1. The rates of loss of score of butters made from creams of different average acidities and stored at various temperatures.

TABLE 2

Scores and remarks of scorers on the various samples of butter stored for various periods of time at −17° C.

Sample No.	Acidity % Lactic	Initial		At 90 days		At 180 days		At 270 days		At 360 days	
		Score	Remarks	Score	Remarks	Score	Remarks	Score	Remarks	Score	Remarks
1–A	.13	92.0	Clean, flat	91.5	Stale	91.5	…	90.5	…	88.0	…
2–A	.13	92.0	Sl. coarse	92.0	…	91.0	…	88.0	…	88.0	…
3–A	.13	92.0	…	92.0	…	90.0	…	89.5	Stale, oily	…	…
4–A	.14	91.5	Sl. oily	90.0	…	91.0	…	88.0	…	…	…
5–A	.12	91.0	Oily, foreign	91.5	…	91.0	…	87.5	…	…	…
1–B	.185	91.5	…	91.0	…	91.0	…	90.0	…	89.0	…
2–B	.18	92.0	…	92.0	…	90.0	…	88.0	…	…	…
3–B	.195	92.0	Clean, flat	92.5	…	91.5	…	88.0	…	…	…
4–B	.18	92.0	…	92.0	…	91.0	…	88.0	…	…	…
5–B	.20	92.5	Aroma, flavor	91.5	…	90.0	…	89.5	Stale, oily	88.0	…
6–B	.195	92.0	…	92.0	…	90.0	…	89.5	…	89.0	…
7–B	.20	91.0	Over-ripe, str. flavor	91.0	Sl. oily	91.5	…	90.0	…	89.0	…
8–B	.20	91.0	Oily	91.0	…	91.0	Oily	90.0	…	88.5	…
1–C	.30	92.5	Starter aroma & flavor	90.0	Metallic	91.0	…	88.0	…	…	…
2–C	.36	92.0	…	90.0	…	90.0	…	90.0	…	88.0	…
3–C	.30	92.0	Over-ripe flavor, aroma	91.+	Sl. oily	90.0	Sl. oily	89.0	Stale	88.0	…
4–C	.30	92.0	…	91.5	…	91.0	…	88.0	…	…	…
5–C	.30	91.5	…	92.0	…	89.0	…	87.0	…	…	…
1–D	.37	91.5	Sl. oily	89.5	Metallic	91.0	…	87.5	…	…	…
2–D	.46	90.0	Oily, sl. metallic	88.0	Sl. metallic	88.0	…	86.0	…	…	…
3–D	.43	92.0	Str. aroma, sl. oily	88.0	…	88.5	…	87.0	Fishy	…	…
4–D	.40	91.5	Oily	90.0	…	90.0	Aged	87.0	…	87.0	…

different temperatures of storage, the surface layer was discarded in each case before the samples to be tested were taken. After scoring, the remainder of each sample was melted at about 50° C. and the fat filtered. This fat was then used in the various tests.

The data obtained are given in the following tables and charts. The results upon each individual sample are of no particular interest, hence the averages for the samples in each particular group have been used, except in the matter of "remarks by the scorers," which of course does not lend itself to such treatment. The remarks of the scorers are given in tables 2, 3, 4 and

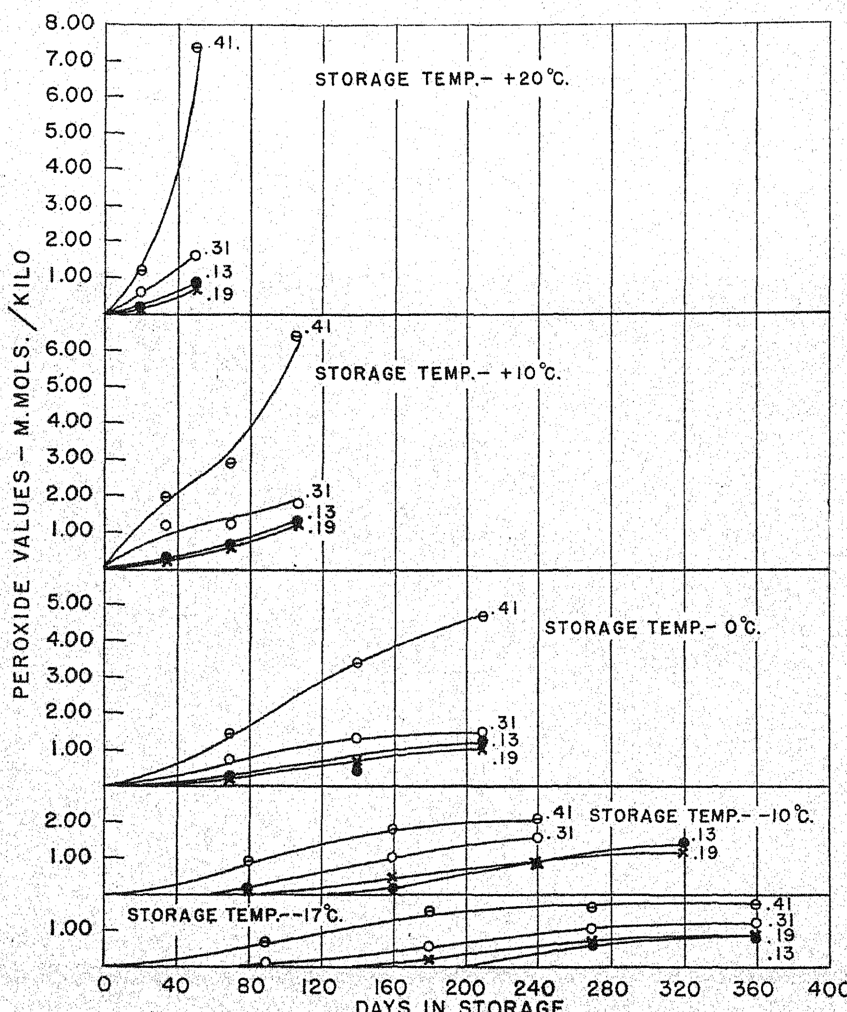

FIG. 2. The rates of peroxide formation in butters made from creams of different average acidities and stored at various temperatures.

5. Their especial significance will be discussed later. In Table 1 are given the averages of the values obtained with each test upon the samples of butter in the various groups.

Since the periods of storage between tests varied with storage temperature, it is difficult to obtain a true comparison of the rates of variation in the values from this table. Such a comparison may be made with the aid of the following graphs. The values in Figure 1 indicate the relative rate of loss in score in butters from creams of different average acidity, when the butters are stored at the indicated temperatures.

The first marked difference is that of rate of loss in score by the samples of different acidities, at each temperature of storage; except in the case of butters made from creams of 0.13 and of 0.19 per cent average acidity.

The graphs indicate further that the rates of deterioration at the lower temperatures are not constant but progress very slowly for a period of time—the length of this phase being determined by the temperature of storage—then accelerate. No "period of induction" for the changes that take place were noted in those samples stored at 10° and 20° C.

The primary stage of oxidation of fats is the addition of oxygen to the unsaturated bonds of the unsaturated acid components, to form peroxides as follows:

$$\begin{array}{c} \\ \\ -C-C=C-C- \xrightarrow{O_2} -C- \end{array}\begin{array}{ccc} O & - & O \\ | & & | \\ C & - & C \end{array}\begin{array}{c} \\ \\ -C- \end{array}$$

These compounds are stable at ordinary temperatures in relatively low concentrations, and their amounts may be determined accurately through their ability to liberate iodine from potassium iodide in acid solution (9). Further oxidation of these compounds results in splitting of the acid with formation of compounds possessing tallowy flavors and odors. The rates of the formation of peroxides in the different butters are shown in Figure 2.

As in the case of the experiments in which the drop in score was used as a criterion of deterioration, those butters made from creams of 0.13 and 0.19 per cent average acidity show the same rate of deterioration when judged by the rate of peroxide formation. With increases in the acidity of the cream to 0.31 and 0.41 per cent, respectively, the rate of oxidation increased.

The results obtained with the bleaching test were not so consistent as those already given, but show the same order of the rates of deterioration for the different samples as was shown by the same samples of butter when judged by the loss in score or by the rate of peroxide formation.

Of the three tests discussed the peroxide value and the bleaching test relate definitely to oxidation. The score may reflect deterioration by oxidation, but is considered as a test which takes into consideration defects that may be the result of a number of different causes. Hence, to understand the type of deterioration which led to a loss in score in any particular sample,

TABLE 3

Scores and remarks of scorers on the various samples of butter stored for various periods of time at −10° C.

Sample No.	Acidity % Lactic	At 80 days		At 160 days		At 240 days		At 320 days	
		Score	Remarks	Score	Remarks	Score	Remarks	Score	Remarks
1–A	.13	92.0	....	92.0	....	90.5	....	88.5	Stale
2–A	.13	92.0	....	91.0	Oily	90.0	....	89.0	....
3–A	.13	92.0	....	91.0	....	91.0	....	91.0	....
4–A	.14	91.5	Very fine	90.0	....	....	Stale	89.0	....
5–A	.15	91.0	Fine, clean	90.5	....	89.0	Stale	88.0	....
1–B	.185	91.5	....	91.0	Sl. oily	90.0	Stale, oily	89.0	Stale
2–B	.18	91.5	Clean	90.0	....	89.0	Stale	87.0	....
3–B	.195	92.0	....	91.5	Sl. oily	90.0	....	88.5	....
4–B	.18	92.0	....	91.0	Oily	90.0	....	89.0	....
5–B	.20	92.0	....	91.0	....	91.0	....	90.5	....
6–B	.195	91.5	....	91.0	....	90.0	Stale	88.0	Stale, oily
7–B	.20	91.0	....	90.5	....	88.0	Stale, oily	....	....
8–B	.20	91.0	....	89.0	....	89.0	....	89.0	....
1–C	.30	91.0	....	91.0	....	88.0	....	....	....
2–C	.36	91.0	....	91.0	....	88.0	Stale	....	....
3–C	.30	91.0	....	88.0	Cooked, curdy, old	88.0	Fishy	....	....
4–C	.30	92.0	....	90.0	....	....	Stale	....	....
5–C	.30	92.0	Fine	90.0	Sl. aged	88.5	Stale, oily	....	....
1–D	.37	90.0	Sl. metallic	91.0	Oily	88.0	....	....	....
2–D	.46	88.0	Metallic	90.0	Stale, oily	87.0	....	....	....
3–D	.43	88.0	Metallic	90.0	Old, oily	87.0	Fishy	....	....
4–D	.40	91.5	Metalic	90.5	Aged	87.0	Fishy	....	....

TABLE 4

Scores and remarks of scorers on the various samples of butter stored for various periods of time at 0° C.

Sample No.	Acidity % Lactic	At 70 days		At 140 days		At 210 days	
		Score	Remarks	Score	Remarks	Score	Remarks
1–A	.13	91.0	Stale	89.5	Aged	88.0	....
2–A	.13	92.0	....	89.0	Sl. oily	88.0	....
3–A	.13	92.0	....	89.0	Storage flavor	90.0	....
4–A	.14	90.5	Sl. coarse	88.5	....	89.5	Stale
5–A	.12	92.0	Sl. coarse salt	88.5	....	....	Stale, oily
1–B	.185	92.0	....	91.0	Coarse	88.0	Stale, oily
2–B	.18	92.0	....	87.0	Cheesy	87.0	....
3–B	.195	92.0	....	89.0	Oily, sl. bitter	88.5	....
4–B	.18	92.0	....	88.0	Oily, sl. bitter	88.5	....
5–B	.20	92.0	....	89.0	Oily	90.5	....
6–B	.195	92.0	....	91.0	....	88.0	Stale, oily
7–B	.20	92.0	....	90.0	Storage & sl. acid	89.0	....
8–B	.20	92.0	....	92.0	....	88.0	....
1–C	.30	91.0	Stale	87.0	Fishy, greasy	88.0	....
2–C	.36	91.0	Starter flavor	87.5	Fishy	87.5	Stale, oily, sl. metallic
3–C	.30	91.5	....	88.0	Storage, sl. acid	88.0	....
4–C	.30	89.0	S. metallic, soapy	88.5	....	89.0	Stale
5–C	.30	91.5	....	87.0	Cheesy	87.0	....
1–D	.37	90.0	S. metallic	88.0	Oily, sl. metallic	87.0	....
2–D	.46	87.0	Fishy	85.0	Bitter, old, lardy, rancid	84.0	Bleached
3–D	.43	87.0	Fishy	87.0	Old, rancid	87.0	Fishy
4–D	.40	90.0	Sl. metallic	87.0	Fishy	87.0	Stale, oily, sl. metallic

TABLE 5

Scores and remarks of scorers on the various samples of butter stored for varying periods of time at 10 C.

Sample No.	Acidity % Lactic	At 35 days		At 72 days		At 108 days		At 140 days	
		Score	Remarks	Score	Remarks	Score	Remarks	Score	Remarks
1–A	.13	88.5	Cheesy	89.0	Stale, musty	87.0	Moldy	......	......
2–A	.13	89.0	Stale	89.0	Stale, musty	89.0	......	......	......
3–A	.13	90.0	Storage, oily	90.0	Stale	90.0	Stale	89.0	Stale
4–A	.14	......	......	91.0	......	90.5	......	90.0	......
5–A	.12	......	......	90.0	......	89.0	Stale	......	......
1–B	.185	90.0	Storage	90.0	Stale	90.0	Stale	89.0	Stale
2–B	.18	......	......	89.5	Musty	89.5	Cheesy	89.5	Stale
3–B	.195	88.0	Sl. cheesy, old	89.0	Stale, musty	88.0	Stale, sl. moldy	......	......
4–B	.18	90.0	......	89.0	Stale, musty	89.0	......	......	......
5–B	.20	90.5	Old, coarse	89.0	Stale	89.0	Stale	......	......
6–B	.195	90.0	Old, oily	90.0	"	90.0	Stale	89.0	Stale
7–B	.20	90.0	Sl. oily	90.0	"	90.0	......	89.0	Stale
8–B	.20	90.0	Oily	90.0	"	89.5	......	......	......
1–C	.30	89.0	Stale, sl. metallic	88.5	Tallowy	87.0	Fishy	......	......
2–C	.36	89.0	Sl. fishy	88.5	Metallic	88.0	Stale, oily	......	......
3–C	.30	88.5	Old, oily	89.0	Stale	88.0	Stale, oily	......	......
4–C	.30	......	......	90.0	Stale	90.0	......	89.5	......
5–C	.30	......	......	88.0	Stale, oily	88.0	Cheesy, stale, oily	......	......
1–D	.37	88.0	Stale, oily	87.0	Metallic	86.0	Fishy	......	......
2–D	.46	85.0	Fishy, bleached	85.0	Fishy	85.0	Bleached, stale, oily	......	......
3–D	.43	87.0	Fishy	86.0	Bleached, fishy	86.0	Bleached, stale, oily	......	......
4–D	.40	87.5	Stale	88.0	Metallic	88.0	Stale, oily	......	......

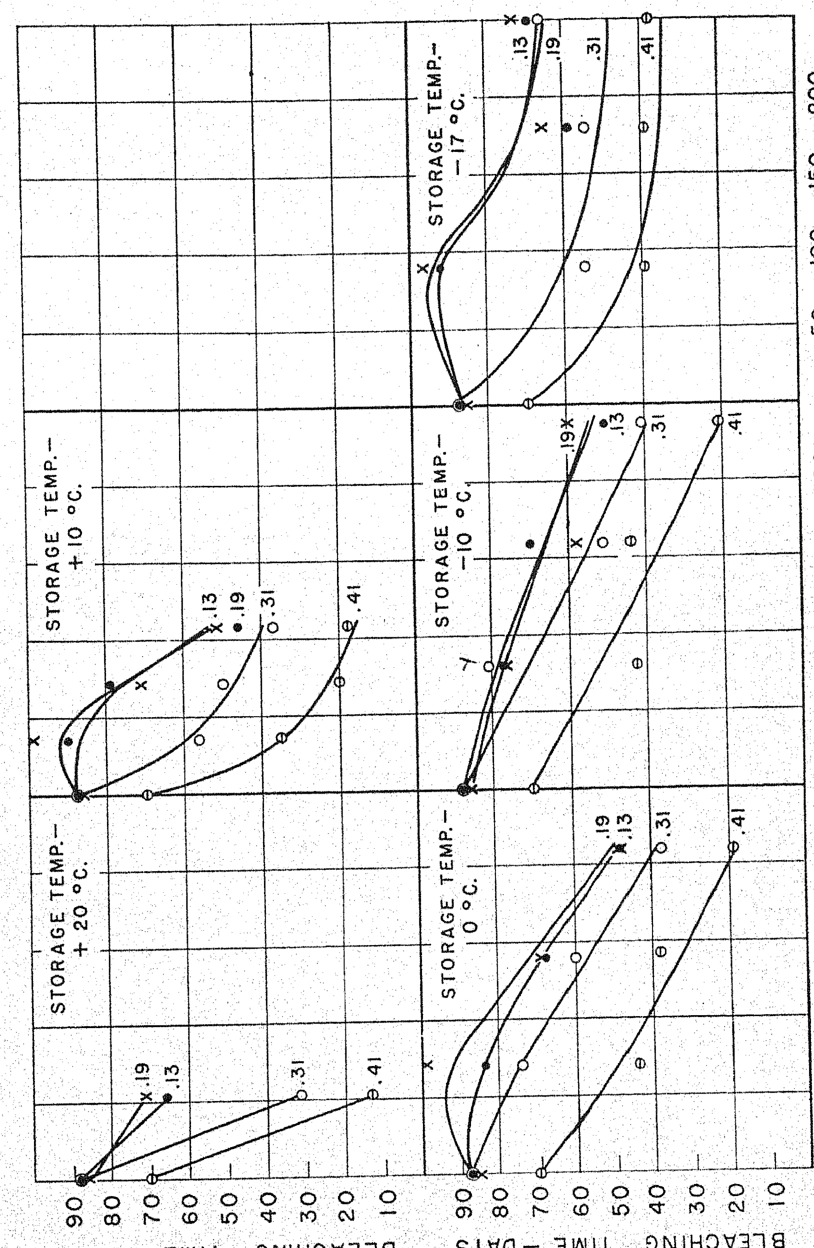

FIG. 3. The time necessary at 42° C. for bleaching of butteroils from butters made from creams of different average acidities and stored at various temperatures.

the remarks of the scorers are of especial value. These are given in Tables 2, 3, 4, and 5.

A survey of these tables indicates little or no difference between the butters made from creams of 0.13 and 0.19 per cent acidity in the type of deterioration during storage. In none of these samples did the scorers note a metallic, tallowy, or fishy flavor, although some samples were stored for 360 days at $-17°$ C. Samples of butter made from 0.30 and 0.40 per cent acid cream possessed metallic flavors and fishy flavors relatively early in the storage period, the time of their occurrence depending upon the temperature of storage and the acidity of the creams from which they were made. Metallic and fishy flavors occurred more frequently and earlier in the storage period in the butters made from creams of 0.40 per cent acidity than in that made from 0.30 per cent acidity.

The relative efficiency of the different temperatures in promoting keeping quality of the different butters may be determined from the values in Table 1. The relative efficiencies have been shown graphically by plotting the time of storage in days required by each butter at each storage temperature, to result in a loss of two points in score.

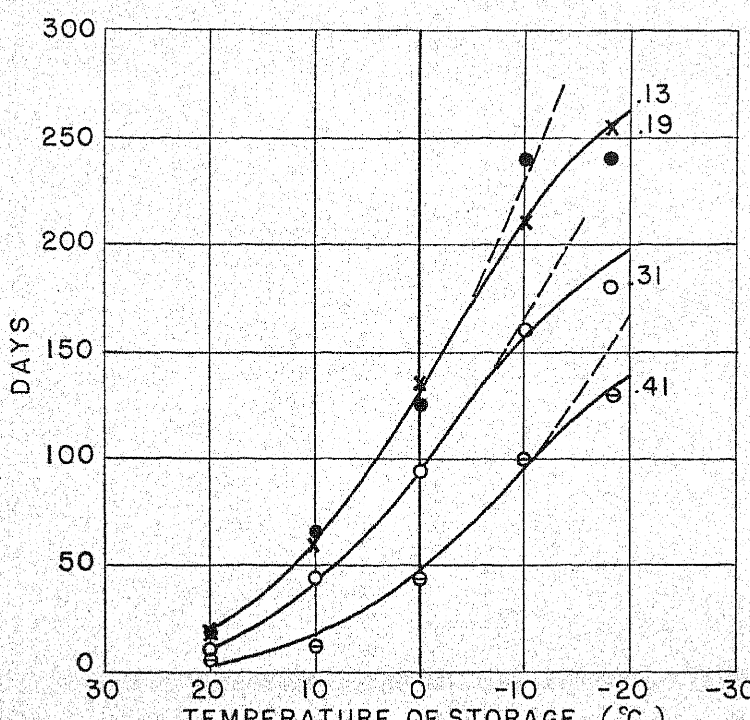

FIG. 4. The number of days of storage necessary at the indicated temperatures to result in a loss of two points in the score of butters made from creams of different acidities.

A decrease of the temperature from $-10°$ C. to $-17°$ C. does not seem to decrease the susceptibility of butters to deterioration to so great an extent as do similar decreases in the higher temperature ranges.

The graphs indicate also in a general manner the relative keeping quality of butters made from creams of different acidities.

DISCUSSION

Butters made from creams of different acidities grouped themselves similarly when their keeping quality was judged by any of the three tests used. In each case practically no difference was noted in the values obtained upon butters from creams of 0.13 and 0.19 per cent acidity at any of the chosen temperatures of storage. In other words, the rates of deterioration of sweet cream butters and of butters made from creams of less than 0.20 per cent acidity, developed by pure cultures added to sweet creams, were practically identical. Whether or not butters made from creams of acidities slightly greater than 0.20 per cent, possess a similar rate is not indicated by the data. Butters made from cream of an acidity of 0.30 per cent or more were found to be inferior in keeping quality to those made from sweet cream.

From the standpoint of reliability in judging deterioration, the score method will probably always be preferred, because of its direct relationship to edibility. However, it may not be directly related to any one type of chemical change and lacks in exact quantitative aspects, especially after the initial deterioration changes have taken place. Below a score of 89 the drop in score does not seem to correlate directly with the magnitude of the chemical changes that take place. This is noted especially in the relationship between scores and peroxide values of the samples stored at 20°, 10° and 0° (see Figs. 1 and 2).

The general similarity in the rates of deterioration, determined by the loss in score and by the development of peroxide, throughout the period of storage, in spite of the fact that in scoring all off flavors and odors are taken into consideration, seems to verify the hypothesis that there is a direct relationship between rate of oxidation and loss in score, or stated more directly, the oxidation reaction seems to underlie the various changes that are responsible for the loss in score.

A measure of the rate of oxidation of a butterfat seems, therefore, to be a direct measure of the rate of deterioration even though the direct end product of this reaction—tallowiness—may not be noted in the scoring.

Fishy flavors and odors in butter have been shown to be caused by an acid medium and especially when accompanied by oxidation promoted by metals (3) (10). The present results verify the conclusion that acids promote this type of deterioration and show also that spontaneous autoxidation will aid its development. However, it appears that an acid medium is the major factor concerned, for the amount of peroxides developed in sweet cream butters was

often equal to or greater at the end of the storage period than the amounts in the acid cream butters when the latter possessed a fishy flavor, yet none of the butters made from cream of an acidity of 0.20 per cent or less developed a fishy flavor. The exact rôle that oxidation may play in the development of fishy flavors is not clear.

The efficiency of different temperatures of storage in promoting keeping quality is shown in Figures 1, 2, and 3. Their relative value is shown in Fig. 4, which seems to indicate that a drop in storage temperature from −10° C. to −17° C. does not result in an increase in keeping quality proportionate to that observed for a similar lowering at a higher temperature range.

ACKNOWLEDGMENT

Mr. C. S. Trimble of this Bureau aided Mr. White in the scoring of the butter samples and we wish to express our appreciation for his assistance.

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SPECIFIC HEAT AND THE PHYSICAL STATE OF THE FAT IN CREAM

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INTRODUCTION

The physical state and alterations in the physical state of the fat in the globules of milk and cream offer the most reasonable explanation for the profound effect of temperature on creaming, cream viscosity, foaming, churning, lipase activity, and surface tension. Many of these effects are reversible and are probably produced or influenced by the materials adsorbed on the surface of the globules when the fat is in different physical states. In order better to understand the influence of temperature on milk products, a knowledge of the physical state and alterations in the physical state of the fat in the globules is necessary. Information obtained by a study of milkfat in mass cannot be used as indicating accurately the physical state of the fat dispersed as globules. Seeding occurring in a mass of fat will influence the crystallization of the whole mass, but in fat dispersed as globules seeding will affect only the fat in the globule in which the crystal happens to form, and will exert no direct effect on the fat in other globules. This leads to a much slower attainment of equilibrium. Furthermore the crystals are larger in fat in mass, as compared with fat in globules, and this influences the rate of solution or melting on heating. Crystallization in both fat in mass and in globules is influenced by the rate of cooling.

A study was undertaken to gain information as to the physical state of the fat in globules at different temperatures and the rate of attainment of a constant physical state at the different temperatures. Determinations of specific heat were used as one method of following the alterations in the state of the fat in the fat globules.

Chevreul (3) observed that the solidification of milkfat was accompanied by the evolution of heat. Fleischmann (5) (6), Fjord (4), Landois (9), Chanoz and Vaillant (2), Schnorf (10), Hammer and Johnson (7), and Bowen (1) have reported specific heat values for milk and cream. The effect of fat has been studied more specifically by Fleischmann (6), Hammer and Johnson (7), and Bowen (1), the latter reporting values obtained by the U. S. Bureau of Standards. There is no assurance that the fat was in equilibrium at the different temperatures used. The use of an ordinary calorimeter involves difficulties when used to determine the specific heat of milk and cream at temperatures within crystallization range, because considerable time is required to attain the equilibrium state, and during this

Received for publication February 5, 1938.

time the heat exchange between the calorimeter and its surroundings makes up an ever increasing part of the total heat measured.

EXPERIMENTAL

Method

The method of mixtures was used, since it avoids the errors due to large values for heat exchange with the surroundings, and has a reputation for high accuracy. Quart thermos bottles were used as containers. Warm water from one bottle was poured into colder cream or milk contained in another. The thermometers used were graduated to 0.1° C. and were calibrated against each other over the range used—from 0 to 75° C. All readings were made with the aid of a magnifying glass and were estimated to 0.02° C. The errors and heat losses in the procedure were studied, and all equipment and procedures were thoroughly standardized. The heat "loss" to the container and during the manipulation was found to be given by the following equation:

$$\text{Loss calories} = K_1(t_f - t_i) + K_2(t_W - t_r)$$

where K_1 and K_2 are constants representing the heat equivalent of the apparatus and heat lost in pouring, respectively,

t_f = final temperature of cream-water mixture,

t_i = initial temperature of the cream,

t_W = the temperature of the warm water before pouring,

and t_r = the temperature of the room.

It was found by experiment that within the normal limits, the relative humidity of the room exerted an effect so small that it could be disregarded. The constants were determined by calibration with water, the room temperatures varying from 23 to 28° C., cold water varying from 5 to 39° C., and warm water varying from 21 to 66° C. The constants were calculated by the method of least squares, and for a typical pair of thermos bottles gave the equation:

$$\text{Loss calories} = 25.35\ (t_f - t_i) + 3.38\ (t_w - t_r)$$

About 150 grams of cream and 250 grams of water were used. The amounts were determined by weighing. The specific heat of water was taken as unity, and after correcting for the heat loss, the specific heat of the cream was calculated.

Results

The specific heat of skimmilk was determined both by the method of mixtures and by means of the conventional calorimeter in which heat was produced by an electric heater immersed in the milk. Within rather narrow limits the same values were obtained by both methods. This indicates that the heat of dilution involved in the method of mixtures is negligible. The average value was found to be 0.943 with only slight deviations for the

various samples over the temperature range studied. The specific heat of the fat in the cream was calculated from the specific heat of the skimmilk, the specific heat and the fat content of the cream.

Cream of about 40 per cent fat content obtained from mixed milk was first warmed to 45° C. and was then cooled rapidly by immersing the container in water the temperature of which was about 5° C. below the final temperature desired for the cream. As soon as the desired temperature of the cream was reached, the temperature of the water bath was adjusted to the temperature of the cream, and an aliquot of the cream was removed at once and its specific heat determined. Determinations of specific heat were continued at intervals until it was evident that a constant value for that particular temperature had been reached. Before introducing the cream into the bottle, the temperature of the thermos bottle was adjusted to that of the cream by means of water. The temperature of the warm water which was poured into the cream was so adjusted that the resulting mixture would

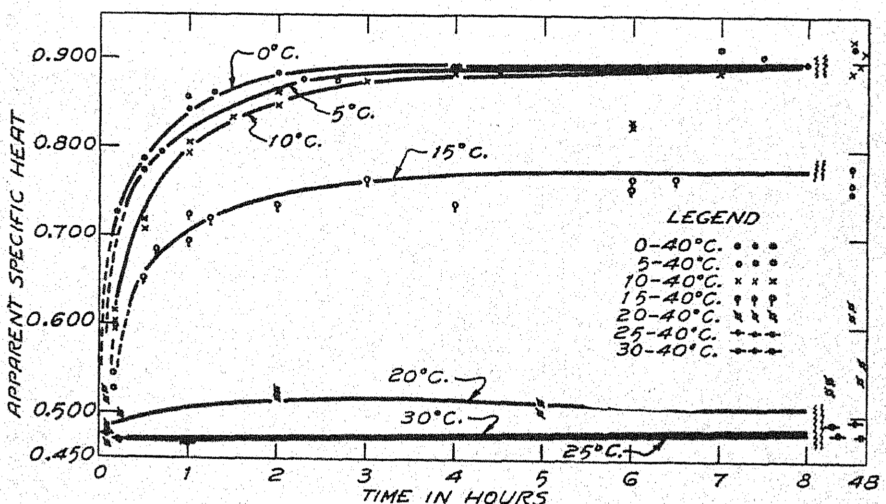

FIG. 1. The apparent specific heat of milkfat in cream held at various temperatures for varying lengths of time.

have a temperature of 40° C. or slightly above. In this way values were obtained for the heat required to warm to 40° C. cream having original temperatures ranging from 0 to 30° C. The specific heat values thus obtained are the average specific heats for the temperature ranges. The specific heat values attributable to the fat alone are presented graphically in Figure 1. This figure indicates that if the cream is cooled rapidly enough the fat at rather low temperatures may for a short time still be liquid and have the specific heat of liquid fat. Crystallization soon begins, however, and continues for about 4 hours, since the specific heat increases for a period of approximately 4 hours. After this time the change is slight.

The effect of season and feed of the cow on the hardness of the fat has been studied by Hunziker, Spitzer and Mills (8) and others. The fat is generally less hard on pasture than on dry feeding. Figure 2 shows that there

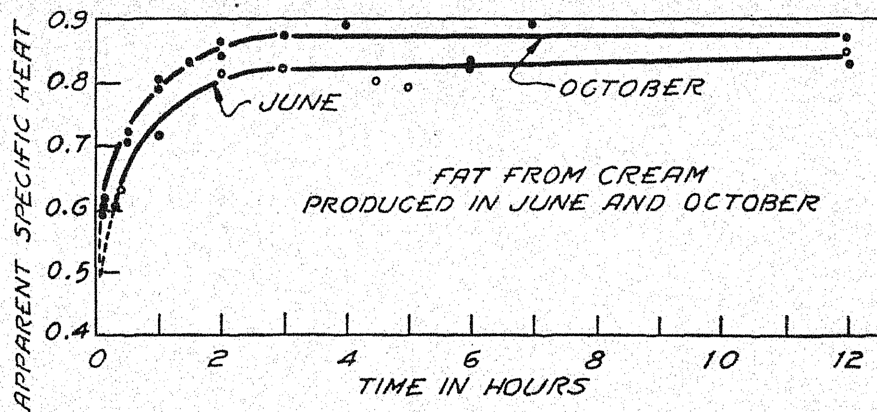

FIG. 2. The apparent specific heat of milkfat in cream produced in the month of June and in October. Cream warmed from 10° to 40° C.

is also a difference in specific heat of the fat in the temperature range in which crystallization of fat occurs.

Aliquots of cream, one at equilibrium at 15° C., the other at equilibrium at 20° C., differ in the number of calories required to warm the cream from equilibrium at 15 to equilibrium at 20° C. by the difference in the amount of heat required to raise each to 40° C., a temperature at which the fat is liquid. Using this procedure, the heat required to raise milkfat from successive equilibrium states at 5° C. intervals in temperature was calculated. In Table I are recorded the average equilibrium specific heat values of the fat calculated

TABLE 1

Apparent specific heat of fat in cream for each 5° C. interval ranging from 0 to 40° C. Milk produced in October and November

Temp. range	Temperature difference	Apparent sp. heat	Heat required	Heat required 5° C. interval	Average sp. heat for interval	Temperature interval
°C.	°C.		calories	calories		°C.
					0.475	30–40
30–40	10	0.475	4.75	2.38	0.475	25–30
25–40	15	0.475	7.13	2.87	0.575	20–25
20–40	20	0.50	10.00	9.25	1.85	15–20
15–40	25	0.77	19.25	7.15	1.43	10–15
10–40	30	0.88	26.40	4.75	0.95	5–10
5–40	35	0.89	31.15	4.45	0.89	0– 5
0–40	40	0.89	35.60			

from the calories required to warm to 40° C. cream held at a series of temperatures. The total number of calories required to warm the fat through the given temperature range was then calculated, and by difference the increments in calories for each 5 degrees. In the next to the last column the average specific heat of the fat in each 5 degree range is given. This table indicates that the apparent specific heat of the fat varies from 0.475 for liquid fat to 1.85 for the temperature range between 15 and 20° C., the range in which the greatest change in physical state occurs. If smaller increments in the region of 15° C. had been taken, still higher values might be obtained. The data in this table are in general agreement with those of Fleischmann (6), Hammer and Johnson (7), and Bowen (1). The data from Table 1 were used to calculate the specific heat increments over the temperature range of from 0 to

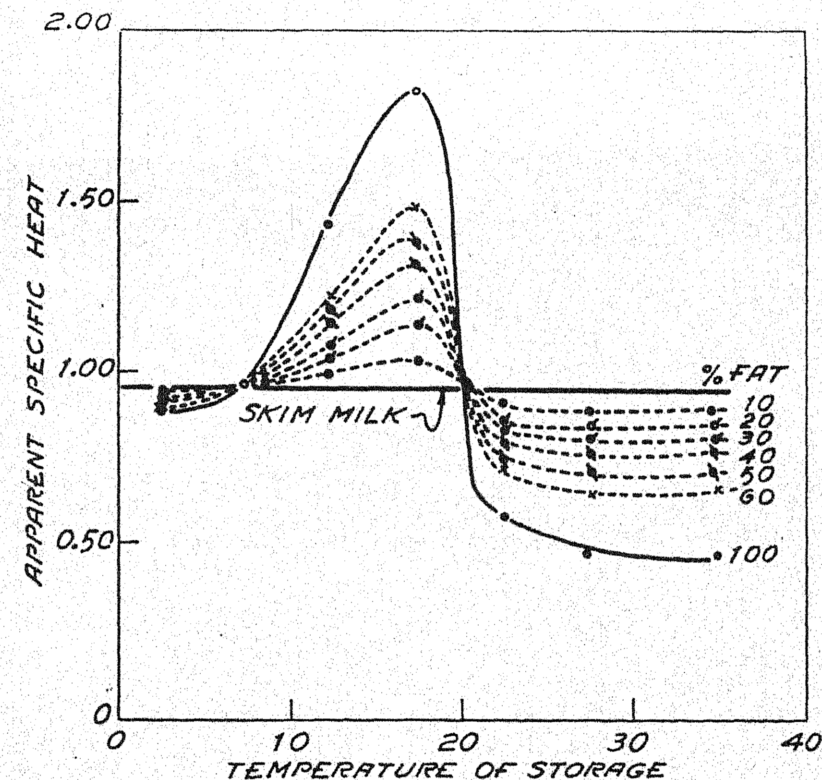

FIG 3. The calculated apparent specific heat of milkfat and of milk and cream, within each 5° C. interval in the 0–30° C. and in the 30–40° C. range. The calculations are based on values obtained on samples which had been stored at the various temperatures for 4 hours.

40° C. of milk and cream containing various percentages of fat, and the results are given in Table 2. The relationships are more readily visualized in Figure 3.

TABLE 2

Specific heat of skimmilk, cream, and milk fat globules for 5° intervals ranging from 0 to 40° C. milk produced in October and November

Temperature interval °C.	Fat content per cent								
	0	5	10	20	30	40	50	60	100
0– 5	.943	.940	.937	.932	.927	.921	.916	.911	.890
5–10	.943	.943	.943	.944	.945	.945	.946	.947	.950
10–15	.943	.967	.991	1.040	1.089	1.138	1.186	1.235	1.43
15–20	.943	.988	1.033	1.124	1.215	1.305	1.396	1.487	1.85
20–25	.943	.924	.905	.869	.832	.795	.758	.722	.575
25–30	.943	.919	.895	.849	.802	.755	.708	.662	.475
30–40	.943	.919	.895	.849	.802	.755	.708	.662	.475

DISCUSSION

The following melting point temperatures are typical of those given in the literature: tristearin 71° C., tripalmitin 65° C., trimyristin 55° C., and triolein –5° C. Stearic, palmitic, myristic and oleic are the principal acid components of milkfat. Milkfat may be considered as a solution which on cooling becomes supersaturated with respect to one or more of the mixed glycerides of which it is composed. The uncertainty and indistinctness of the so-called solidifying point would be expected, since a true solidifying point is not involved. The temperature at which a supersaturated solution begins to crystallize varies with the conditions, such as degree of supersaturation, agitation, seeding, etc. Furthermore, after crystallization starts the rate of crystallization of a solute from its supersaturated solution may vary greatly and crystallization may extend over a considerable period of time. The crystallization of milkfat is still further complicated because on cooling it probably becomes supersaturated with respect to more than one solute. Milkfat can readily be fractionated into one component which will not melt unless heated above 45° C., and into another which will not solidify when cooled to 5° C.

The so-called melting point of milkfat is not definite because we are really dealing with a temperature-solubility relationship. As the milkfat is warmed, the solid glycerides become more soluble in the liquid fractions, and an appreciable increase in solubility is noticed in the region of 15° C., but complete solution is usually not obtained until the fat is heated above 30° C. The rate at which the crystals dissolve is dependent upon their size, which in turn is dependent upon the rate and conditions of the previous cooling. These phenomena are all demonstrable with milkfat in mass.

On cooling, the lag in the formation of the solid phase in milkfat in the globule state is much greater than for fat in mass.

The alteration of the specific heat of cream with time was used as a method

for following the rate of formation of solid milkfat at the various temperatures. Below 20° C., the greater part of the crystallization is complete in about four hours. This is in agreement with some experiments carried out by Troy and Sharp (11), who showed that solidification of the fat globules, as indicated by resistance to pressure in the centrifuge, was not complete in two hours, but was complete in five hours, at 3° C.

CONCLUSIONS

1. The method of mixtures is a reliable method for the determination of specific heat of cream within the range in which a change in the relative amounts of crystalline and liquid fat occurs.

2. When cream is cooled to temperatures within the range of 0 to 20° C., the phase adjustment is nearly complete in about 4 hours, so far as this is indicated by the specific heat.

3. The average equilibrium specific heat for milk-fat in the globules for 5° C. temperature intervals is as follows: 0–5° C., 0.89; 5–10° C., 0.95; 10–15° C., 1.43; 15–20° C., 1.85; 20–25° C., 0.575; 25–40° C., 0.475; for fat in milk produced in October and November.

4. A variation in the specific heat of the milkfat with feed or season was shown.

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BOUND WATER AND ITS RELATION TO SOME DAIRY PRODUCTS.

II. FACTORS AFFECTING THE BOUND WATER CONTENT OF SOME DAIRY PRODUCTS*

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Evidence that liquid dairy products contain bound water was presented in the first of this series of studies on bound water (1). There was also some indication that the bound ⇌ free water equilibrium could be changed readily by various treatments. Sayre (2) states that "Bound water does not exist in definite proportions relative to the solid material of the system, but as a ratio between bound water and free water. The ratio may be changed quickly by varying the temperature, acidity, surface energy, presence of electrolytes, pressure, etc."

Since the degree of hydration plays a rôle in giving colloidal stability to the product in question, it was thought advisable to determine some of the factors that influence the bound water content. If the product in question lacks colloidal stability, during or after manufacture, in many cases a partial precipitation of the proteins may occur. It can be readily seen that the nature of some of the defects that occur in ice cream, milk, evaporated milk, sterilized cream, etc., are usually associated with the ability of the milk proteins to bind water or to readsorb water after certain necessary treatments.

It has been known for a long time that certain effects are produced by various treatments of dairy products but just what causes some of these effects has never been definitely established. Therefore, a study of the factors affecting the bound water content of some dairy products was undertaken in the hope that some of these phenomena might be explained more fully.

EXPERIMENTAL METHODS

The samples used, unless otherwise stated, were obtained from the same sources as previously mentioned (1). The experimental methods used were described before (1).

The data on aging, viscosity and protein stability given throughout this work will be dealt with in detail in the last paper of this series.

Received for publication February 9, 1938.

* Authorized for publication on January 22, 1938, as paper No. 823 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

** The data presented in this paper are from a thesis submitted to the Graduate School of The Pennsylvania State College in partial fulfillment of the degree of Doctor of Philosophy, 1937.

The Effect of pH on the Bound Water Content of Casein Sols

A study was made of the effect of pH on the bound water content of casein sols. The casein used was pure casein (Pfanstiehl). It was dispersed with sodium bicarbonate to obtain the desired pH values. The effect of increased and decreased pH was determined, using a casein sol at a pH of 6.69 as the control. Table 1 gives a summary of the data obtained on the effect of pH on the bound water content of casein sols.

TABLE 1

The effect of pH on the bound water content of casein sols

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Per cent bound water	Grams bound water per gram solids
1. Casein Sol (pH 5.83)	4	2.79	5.81	1.244	0.125	1.06	0.38
	24	2.79	5.83	1.283	0.125	1.24	0.44
2. Casein Sol (pH 6.69)	4	2.97	6.64	1.679	0.12	2.29	0.77
	24	2.97	6.69	1.718	0.12	2.42	0.81
3. Casein Sol (pH 7.36)	4	3.51	7.34	1.442	0.115	1.37	0.39
	24	3.51	7.36	1.540	0.115	1.77	0.50

The hydrogen ion concentration is probably one of the most important factors involved in the study of the bound water content of dairy products. It probably has a definite influence on the amount of water bound in dairy products since most proteins have well defined isoelectric points or zones.

The studies with casein sols in Table 1 show the importance of optimum pH in order to have maximum bound water content. Increasing or decreasing the pH from the "normal" brings about a decrease in the bound water content. A decrease in pH appears to be slightly more detrimental to the bound water content than an increase in pH.

The Effect of pH on the Bound Water Content of Concentrated Milk Plasma

The pH of normal ice cream mixes made from fresh products is usually between 6.2 and 6.4. Since pH plays such an important part in protein stability, it was thought that altering the pH of a concentrated milk plasma would affect the bound water content. Sodium bicarbonate was used to change the pH in the two samples. The pH of the fresh control was 6.22 which is normal for an ice cream mix. The results of these trials appear in Table 2.

Increasing the pH in the range studied has a marked effect on the water binding capacity of the concentrated milk plasma as can be seen from Table 2. A decrease in the bound water content resulted when the pH was increased to neutrality and slight alkalinity. It will be noted that although

TABLE 2

The effect of increasing the pH on the bound water content of concentrated milk plasma

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Conc. Milk Plasma pH 6.22	0	17.57	6.22	5.590	0.38	7.2	6.10	0.347
	4	17.57	6.24	6.183	0.375	7.3	6.76	0.384
	24	17.57	6.22	7.051	0.375	7.4	8.12	0.462
2. Conc. Milk Plasma pH 7.05	0	17.01	7.05	6.183	....	9.1	4.78	0.281
	4	17.01	7.08	5.293	....	8.9	5.60	0.323
	24	17.01	7.08	6.459	....	9.2	6.62	0.383
3. Conc. Milk Plasma pH 7.35	0	17.31	7.35	6.183	....	9.4	3.86	0.223
	4	17.31	7.37	6.755	....	9.2	4.77	0.275
	24	17.31	7.37	6.459	....	9.5	4.05	0.234

a decrease in bound water content resulted on increasing the pH, the protein stability as measured by the alcohol number increased.

Another series of samples was made and the effect of decreasing the pH on concentrated milk plasma was determined. Lactic acid was used to lower the pH of the samples.

The pH was decreased to 5.97 and 5.19 while the pH of the control was 6.31. The results of these mixes are recorded in Table 3.

TABLE 3

The effect of decreasing the pH on the bound water content of concentrated milk plasma

Sample	Hours aged at 40° F.	Per cent solids	pH	Vis cosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Conc. Milk Plasma pH 6.31	0	14.75	6.31	5.293	0.300	7.8	2.37	0.161
	4	14.75	6.32	5.590	0.290	7.8	3.69	0.250
	24	14.75	6.32	5.886	0.290	7.7	5.37	0.364
2. Conc. Milk Plasma pH 5.97	0	15.14	5.97	4.701	0.575	3.0	0.31	0.020
	4	15.15	6.05	4.997	0.560	3.0	1.76	0.116
	24	15.14	6.05	5.590	0.560	3.0	3.08	0.203
3. Conc. Milk Plasma pH 5.19	0	15.14	5.19	4.701	0.590	2.0	0.11	0.007
	4	15.14	5.23	4.997	0.590	1.6	2.17	0.143
	24	15.14	5.23	4.997	0.595	1.5	1.72	0.113

It is very evident that a decrease in pH in the range studied decreases the bound water content of concentrated milk plasma. It is logical to believe that further decreases in pH toward the isoelectric zone would decrease the bound water content still more and that it should be at a minimum at the isoelectric point. It appears then that the phenomenon of precipitation is accompanied by a decrease in the bound water content.

It will be noted also that with the decrease in bound water content there was a decrease in viscosity and protein stability.

The Effect of Concentration on the Bound Water Content of Casein Sols

The casein used for this study was pure casein (Pfanstiel). It dispersed readily when the pH was adjusted with sodium bicarbonate. Sodium caseinate was undoubtedly formed which is more soluble than calcium caseinate and probably binds more water, but the results nevertheless indicate the effect of concentration on the bound water content of these casein sols. These results are recorded in Table 4.

TABLE 4

The effect of concentration on the bound water content of casein sols

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Per cent bound water	Grams bound water per gram solids
1. Casein Sol (1.67%)	4	1.67	6.98	1.185	0.07	1.46	0.87
	24	1.67	6.97	1.244	0.07	1.53	0.92
2. Casein Sol (3.35%)	4	3.35	6.91	1.718	0.11	2.33	0.70
	24	3.35	6.89	1.758	0.11	2.50	0.75
3. Casein Sol (6.71%)	4	6.71	6.83	4.345	0.24	3.54	0.53
	24	6.71	6.81	4.444	0.24	4.42	0.66

The bound water content per gram of casein tends to diminish with the concentration of the casein sol. In general, it is known that a hydrophilic colloid will bind more water per gram of substance in dilute solution. Casein, then, acts like a hydrophilic colloid in this respect and seems to show that bound water is closely associated with concentration. Chrysler (3), working with kelp, has found similar results. Newton and Martin (4), experimenting on some colloidal sols, show that in most cases the water bound per gram of colloid tends to diminish with the concentration of the sols.

The Effect of Varying Temperatures on the Bound Water Content of Concentrated Milk Plasma

It is well known that the temperature of pasteurization of dairy products affects the physico-chemical properties of the product. It seems probable that varying temperatures would affect the bound water content. Certain high heat treatment is known to favor protein stability with alcohol but what effect it has on hydration has not been definitely known.

Three samples of concentrated milk plasma were compared. The control was heated to 145° F. for 30 minutes while another sample was heated to 175° F. for 5 minutes and the third sample was boiled for one minute. The data for this experiment are given in Table 5.

It will be seen in Table 5 that the higher heat treatment reduced the bound water content of the concentrated milk plasma. It would seem natural to expect that at high temperatures the colloidal micelles are partially

TABLE 5

The effect of heat treatment on the bound water content of concentrated milk plasma

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Heated 145° F.	0	13.80	6.38	3.970	0.29	7.9	4.01	0.291
for 30 min.	4	13.80	6.38	4.108	0.285	8.0	4.73	0.343
	24	13.98	6.38	3.239	0.285	8.0	2.56	0.183
2. Heated 175° F.	0	13.98	6.31	3.516	0.285	8.0	3.42	0.245
for 5 min.	4	13.98	6.36	3.832	0.28	8.1	4.41	0.315
	24	13.98	6.38	3.239	0.285	8.0	2.56	0.183
3. Boiled one minute	0	14.29	6.27	3.970	0.29	8.2	2.51	0.176
	4	14.29	6.33	4.108	0.29	8.3	3.28	0.230
	24	14.29	6.34	3.970	0.29	8.2	2.71	0.190

dehydrated and therefore a decrease in bound water content results. At the higher temperatures it will be seen that the protein stability as measured by the alcohol number increased but slightly. It will also be noted that the bound water content was lower after 24 hours of aging at 40° F. than after 4 hours of aging.

The Effect of Heat on the Bound Water Content of the Fat Globule "Membrane" and Pure Milk Phospholipids

Perlman (5) and Jack (6) have shown the effect of heat on the milk phospholipids. The latter worker believes that the action of heat is a denaturation process in removing the phospholipids from the surface of the fat globules. The writers have further observed that when cream containing approximately 50 per cent of butterfat is heated to 160° F. or higher, some "oiling off" of the fat will result if the cream is not stirred.

Fat globule "membrane" was prepared from washed cream as previously mentioned (1). To note the effect of heat on the bound water content of this material, samples were prepared and heated to various temperatures and aged 4 and 24 hours at 40° F. The samples used were: (1) unheated

TABLE 6

The effect of heat on the bound water content of the fat globule "membrane"

Sample	Hours aged at 40° F.	Per cent solids	pH	Per cent bound water	Grams bound water per gram solids
1. Unheated	4	2.52	6.32	1.55	0.615
	24	2.52	6.05	1.77	0.702
2. Heated to 143° F. for 30 min.	4	2.42	6.53	1.38	0.570
	24	2.42	6.43	1.50	0.619
3. Heated to 160° F. for 5 min.	4	2.49	6.63	0.90	0.361
	24	2.49	6.58	1.06	0.426

control; (2) heated to 143° F. for 30 minutes; and (3) heated to 160° F. for 5 minutes. The bound water studies and other observations are given in Table 6.

The effect of heat on the fat globule membrane is similar to that obtained for other fluid dairy products. A slight decrease of bound water content was obtained when the membrane material was heated to 143° F. for 30 minutes. A temperature of 160° F. for 5 minutes decreased the bound water content markedly.

Some observations on the appearance and odor of the material on heating indicate that some chemical change took place. The unheated control had the appearance of rich milk, had a creamy consistency and gave off no odor, while the sample heated to 143° F. for 30 minutes was lacking somewhat in creamy appearance and gave off a slight sulfur odor. The sample heated to 160° F. for 5 minutes was completely bleached in color, had a watery consistency and gave off a strong odor of sulfur similar to hydrogen sulfide.

An increase in pH and a decrease in acidity occurred on heating the fat globule "membrane." Possibly this reduction in acidity is due to the liberation of carbon dioxide. The viscosity studies show that there was a noticeable decrease on heating. This may have some bearing on the decrease in viscosity of cream on pasteurization.

The effect of heat on the bound water content of pure milk phospholipids was also studied. The pure milk phospholipids material was made as previously mentioned (1). The same temperatures of heating were used as in the previous experiment on the fat globule "membrane." Table 7 shows the results obtained in this experiment.

TABLE 7

The effect of heat on the bound water content of pure milk phospholipids

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Per cent bound water	Grams bound water per gram solids
1. Unheated	4	0.66	6.83	2.163	0.005	3.53	5.35
	24	0.66	6.82	2.204	0.005	3.95	5.98
2. Heated to 143° F. for	4	0.65	6.84	2.104	0.005	3.11	4.78
30 min.	24	0.65	6.82	2.102	0.005	3.34	5.14
3. Heated to 160° F. for	4	0.66	6.83	2.041	0.005	2.64	4.00
5 min.	24	0.66	6.82	2.081	0.005	2.92	4.42

The data in Table 7 show that heat lowers the bound water of pure mik phospholipids. It will be noted again with the temperatures used that the greatest reduction in bound water content occurs between 143° F. and 160° F.

The viscosity of the phospholipid sols decreased on heating to elevated

temperatures. From the results obtained it can be stated that certain high temperatures decrease the bound water content and viscosity of the fat globule "membrane" and pure milk phospholipids.

The Effect of Pasteurization and Homogenization on the Bound Water Content of Twenty-Two Per Cent Cream

A study with cream was undertaken to show the effect of pasteurization and homogenization on the bound water content. A sample of cream was divided into three lots as follows: (1) control of unheated cream; (2) cream heated to 143° F. for 30 minutes; and (3) cream homogenized with a pressure of 2000 pounds at a temperature of 143° F. These data are given in Table 8.

TABLE 8

The effect of pasteurization and homogenization on the bound water content of cream

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Per cent bound water	Grams bound water per gram solids
1. Raw Cream	4	28.53	6.64	7.285	0.15	4.12	0.144
2. Heated to 143° F. for 30 min.	4	28.77	6.66	6.326	0.14	4.01	0.139
3. Homogenized (2000 lbs.)	4	27.83	6.62	28.530	0.135	3.56	0.128

The pasteurization of cream is known to have a detrimental effect upon viscosity and this fact is borne out in Table 8. At the pasteurization temperature used, it is also evident that a small reduction in bound water content occurred.

Homogenization of cream at a temperature of 143° F. and a pressure of 2000 pounds markedly increases the viscosity and decreases the bound water content. The clumping of the fat globules apparently exerts an influence on the protein stability and bound water.

From this study it can be concluded that raw cream contains more bound water and has a higher viscosity than pasteurized cream. Homogenization decreases the bound water, but markedly increases the viscosity.

The Effect of Homogenization on the Bound Water Content of "Ice Cream Mixes"

Some of the effects produced by homogenization in milk and cream are: (1) stabilization of the fat emulsion; (2) destabilization of the protein; (3) increase in surface tension; (4) increase in titrable acidity; or (5) decrease in pH; and (6) increase in viscosity, normally thought to be due to the increase in volume of the disperse phase together with the adsorbed layer and the tendency of the fat to clump.

A "mix" was made containing 14.75 per cent of fat, 12.15 per cent serum solids and distilled water, the sugar and the gelatin being omitted. This "mix" was divided into four portions and treated as follows: (1) homogenized at 0 pounds pressure; (2) homogenized at 1500 pounds pressure; (3) homogenized at 3000 pounds pressure (single valve); and (4) homogenized at 3000 pounds and then at 700 pounds pressure (dual homogenization). The bound water determinations were made in the usual manner and the results are given in Table 9.

TABLE 9

The effect of homogenization on the bound water content of "ice cream mixes"

Mix pressure	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. 0 lbs.	0	26.90	6.43	7.940	0.27	7.4	5.14	0.191
	4	26.90	6.43	9.125	0.27	7.4	5.56	0.207
	24	26.90	6.45	8.829	0.275	7.4	5.29	0.197
2. 1500 lbs.	0	27.01	6.39	12.938	0.275	7.2	2.43	0.090
	4	27.01	6.41	14.123	0.275	7.2	3.22	0.119
	24	27.01	6.42	14.715	0.280	7.2	3.79	0.140
3. 3000 lbs.	0	27.01	6.39	45.293	0.280	7.0	1.96	0.075
	4	27.01	6.41	52.641	0.285	7.0	2.23	0.083
	24	27.01	6.41	53.233	0.285	7.1	3.47	0.128
4. 3000 and 700 lbs.	0	27.01	6.42	10.499	0.275	7.3	5.65	0.209
	4	27.01	6.41	12.799	0.275	7.3	5.93	0.220
	24	27.01	6.41	12.409	0.280	7.4	6.18	0.229

It will be noted from Table 9 that the greater the homogenization pressure (single valve) the greater was the decrease in bound water content and protein stability. It is also apparent that as the viscosity increased due largely to fat clumping (sample 3) there was a decided reduction in bound water content. When the fat clumping and viscosity were decreased by the dual homogenization process (sample 4) a marked increase in bound water content was noted when compared to sample 3.

The fat clumping is undoubtedly largely responsible for the increased viscosity obtained on homogenization, and from the data presented it becomes apparent that the bound water content of these "ice cream mixes" decreases on increased fat clumping and that where dual homogenization is practiced an increase in bound water content and protein stability result.

The Effect of Freezing Milk Plasma on the Bound Water Content

Anderson and Pierce (7) found that after two or three months of storage in a frozen state milk proteins began to precipitate and there seemed to be a slight chemical reaction occurring.

Munkwitz, Berry and Boyer (8) show that freezing causes a partial precipitation of the milk solids; that albumin is precipitated in the greatest

amount, followed in order by lactose, total protein, ash, casein and fat; that with the exception of the fat, the amount of precipitation of the solids increases as the length of time of freezing increases; that freezing causes the fat globules to clump together, and become distorted and irregular in size and shape.

Under the usual conditions of freezing and thawing, the casein of milk, being hydrated, retains its normal degree of dispersion, but when the milk is held in the frozen state over long periods of time, various workers have found that the casein gradually precipitates. It is possible that its hydrophilic properties are changed during storage in a frozen state.

Webb and Hall (9) found that if whole milk is condensed $2\frac{1}{2}$ to 3 times its normal concentration and is then frozen, it may be kept in storage at $-13.3°$ C. (8° F.) or below and reconstituted at any time within about 6 weeks to give a satisfactory fluid milk. Increased milk concentration, higher storage temperatures, or longer periods of storage tended to produce a gelation of the product due apparently to changes in hydration of the casein.

Webb and Hall (10) also found that holding skimmilk in a frozen condition increased the heat stability at 120° C. up to 17 weeks, after which time the heat stability declined. Condensed skimmilk (18% M.S.N.F.) increased in heat stability up to 7 weeks, but subsequently became progressively unstable. They also state that slow freezing of milk or cream caused a gradual precipitation of the caseinate system and an immediate destruction of the fat emulsion.

Doan and Baldwin (11) state that, "Freezing *per se* has no measurable effect on the protein dispersion. Holding in the frozen condition for several weeks or months is required definitely to cause aggregation, denaturation or instability of the proteins."

The effect of long periods of storage in the frozen condition ($-15°$ C.) on the bound water content of skimmilk and condensed skimmilk ($2\frac{3}{4}$ to 1) was studied. Whole milk and cream were also frozen with the intention of determining bound water content but due to destabilization of the butterfat on thawing, accurate solids determinations could not be made and this part of the experiment was therefore discarded.

The samples of skimmilk and condensed skimmilk were frozen and stored at -10 to $-15°$ F. in quart cardboard containers and thawed at room temperature. The skimmilk had been pasteurized at 143° F. for 30 minutes previous to freezing. The results of these experiments are given in Table 10.

The results indicate that holding skimmilk relatively long periods of time in the frozen condition has no great effect upon the alcohol stability of the proteins, but with the condensed skimmilk destabilization occurred. The bound water content of the skimmilk increased slightly and at the 60 day determination it reached its maximum and remained the same up to the 85th day determination. A slight decrease in bound water occurred when determined on the 147th day.

TABLE 10

The effect of freezing milk plasma on the bound water content

Sample	Days frozen	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water
1. Skimmilk	0	9.06	6.55	1.775	0.195	8.5	2.13
	30	9.02	6.45	1.837	0.175	8.5	2.24
	60	9.05	6.43	1.877	0.175	8.5	2.36
	85	9.05	6.43	1.877	0.175	8.5	2.36
	117	9.06	6.48	1.735	0.175	8.3	2.13
	147	9.06	6.49	1.694	0.170	8.2	2.01
2. Condensed Skimmilk	0	25.33	6.15	7.650	0.58	5.4	11.62
	25	25.36	6.05	7.750	0.58	5.5	12.17
	57*	....	....	....	....	.....	....

* Partial precipitation of the casein on thawing.

The condensed skimmilk increased in bound water when stored in the frozen condition for 25 days. After 57 days a marked precipitation of the proteins occurred. Although bound water determinations could not be made, a decrease in the bound water content probably took place. These results parallel the work of Webb and Hall (10), previously cited, on the heat stability of frozen skimmilk and frozen condensed skimmilk.

The Effect of Added Salts on the Bound Water Content of Concentrated Milk Plasma and of Cream

According to the Sommer and Hart theory of Salt Balance (12), citrates and phosphates usually increase heat stability of milk proteins while calcium and magnesium are usually detrimental in their effect on stability. Since stability is usually associated with the proteins and salt balance, it is reasonable to believe that these stabilizing and destabilizing salts should produce some effect upon the bound water content of dairy products, especially in ice cream mix, evaporated milk and coffee cream.

To the writers' knowledge very little work has been done with the effect of added salts on the hydration of the proteins. The effect of hydration is relatively important in ice cream mixes. If the salt balance is not proper in an ice cream mix there is a tendency for the proteins to precipitate upon homogenization and from the standpoint of coffee cream there is a tendency for the cream to "feather" in the coffee. The use of salts is prevalent in the evaporated milk industry. The proteins of evaporated milk have a tendency to precipitate on sterilization if the salts are not in proper balance.

Sommer (13) shows that proteins can be precipitated by "salting out" and that this process is known to exert a dehydrating effect. He further states that citrates and phosphates have a hydrating effect on casein while calcium decreases its hydration.

Sommer and Young (14) reported that upon adding 0.40 and 0.56 per cent of sodium citrate or 1.26 per cent di-sodium phosphate the ease of whip-

ping ice cream mixes was greatly increased, while 0.1 and 0.2 per cent calcium lactate had a noticeable effect and 0.5 per cent had a marked effect in reducing the ease of whipping of ice cream mixes. Later Sommer (15) found that these results could not always be duplicated.

Hening and Dahlberg (16) added sodium citrate, potassium oxalate (poisonous), and di-sodium phosphate to ice cream before pasteurization, and homogenization and obtained a lower viscosity and a greater whipping ability. Calcium lactate increased viscosity and fat clumping and made the mix more difficult to whip.

Keith, Rink and Weaver (17) found that the citrate ion greatly decreased the viscosity and fat clumping, and decreased the titratable acidity only very slightly. The stability of the proteins was increased particularly toward precipitation by alcohol. The calcium ion gave exactly opposite results from those of the citrate ion.

The effect of sodium citrate and di-sodium phosphate on the bound water content was determined with concentrated milk plasma. The sample was divided into three parts as follows: (1) control; (2) control plus one per cent N/4 sodium citrate; and (3) control plus one per cent N/4 di-sodium phosphate. These samples were pasteurized at 143° F. for 30 minutes, cooled to 40° F. and determinations made, after aging at 40° F., at 4 and 24 hours. The results are given in Table 11.

TABLE 11

The effect of milk stabilizing salts on the bound water content of concentrated milk plasma

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Control	4	11.87	6.39	2.959	0.24	8.2	4.31	0.363
	24	11.87	6.41	3.020	0.24	8.3	4.64	0.391
2. Sod. Citrate	4	11.81	6.45	3.061	0.225	8.7	4.83	0.409
	24	11.81	6.46	3.122	0.225	8.8	4.95	0.419
3. Di-sodium	4	11.83	6.46	3.020	0.225	8.7	4.95	0.418
Phosphate	24	11.83	6.49	3.102	0.22	8.9	5.42	0.458

The results in Table 11 show that sodium citrate and di-sodium phosphate increase the hydration of the proteins as indicated by a slight increase in bound water content. These stabilizing salts also caused an increase in protein stability. The effects produced on the pH and the acidity do not appear significant although there was a slight reduction in acidity.

The same experiments were repeated using cream instead of milk plasma to note the effects of these stabilizing salts on the bound water content. Table 12 shows the results obtained with these stabilizing salts in cream.

TABLE 12

The effect of milk stabilizing salts on the bound water content of 25 per cent cream

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Control	4	31.44	6.61	8.641	0.13	7.0	5.90	0.188
	24	31.44	6.63	8.741	0.135	7.1	6.18	0.196
2. Sod. Citrate	4	31.16	6.66	7.857	0.12	7.0	6.01	0.193
	24	31.16	6.71	9.387	0.123	7.15	6.43	0.206
3. Di-sodium	4	31.24	6.63	7.714	0.125	7.0	6.04	0.190
Phosphate	24	31.24	6.68	8.877	0.127	7.2	6.43	0.205

The effect of these stabilizing salts on the bound water content of cream is not marked. The results indicate that these salts do increase the bound water content slightly. It appears, therefore, that the effect produced by sodium citrate and di-sodium phosphate is mainly on the substances in the plasma and not on the substances surrounding the fat globules.

The salts antagonistic in their action upon protein stability are the salts of calcium and magnesium. As a rule they are known to have a destabilizing effect upon the milk proteins. The salts used in this study were calcium phosphate (monobasic) and calcium lactate. These salts were added also on a normality basis to concentrated milk plasma which was then pasteurized at 143° F. for thirty minutes after which it was cooled to 40° F. and determinations made after aging 4 and 24 hours.

TABLE 13

The effect of destabilizing salts on the bound water content of concentrated milk plasma

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Control	4	14.26	6.32	3.102	0.310	7.7	7.49	0.525
	24	14.26	6.29	3.449	0.310	7.8	7.73	0.542
2. Monocalcium	4	14.14	6.26	3.020	0.330	6.8	6.96	0.492
Phosphate	24	14.14	6.26	3.245	0.330	6.85	7.07	0.500
3. Calcium Lactate	4	14.22	6.29	3.020	0.310	6.8	7.03	0.494
	24	14.22	6.31	3.265	0.313	6.9	7.17	0.504

The hydration of the proteins as measured by the amount of bound water present shows that the so-called destabilizing salts are only slightly detrimental to the bound water content and the stability of the proteins. Both calcium phosphate and calcium lactate decrease the amount of bound water about the same degree. There was also a considerable decrease in protein stability.

The effect of these destabilizing salts on cream was also studied. The

salts were added in the same amounts as previously described and the cream was also pasteurized at 143° F. for thirty minutes.

TABLE 14

The effect of destabilizing salts on the bound water content of 27 per cent cream

Sample	Hours aged at 40° F.	Per cent solids	pH	Viscosity centipoises	Per cent acid	Alcohol no.	Per cent bound water	Grams bound water per gram solids
1. Control	4	33.61	6.51	13.510	0.155	6.0	5.57	0.166
	24	33.61	6.54	16.531	0.160	6.2	5.82	0.173
2. Monocalcium Phosphate	4	33.27	6.44	13.061	0.170	4.7	4.99	0.149
	24	33.27	6.44	14.898	0.170	4.8	5.13	0.154
3. Calcium Lactate	4	33.25	6.58	12.595	0.165	4.5	4.51	0.136
	24	33.25	6.58	15.000	0.170	4.6	4.62	0.138

The effect of destabilizing salts on the bound water content of cream is noted above. Both salts studied appear to decrease the amount of bound water. This decrease in bound water is accompanied by a decrease in viscosity and a decrease in protein stability.

CONCLUSIONS

The bound water content of a prepared casein sol is greatest at a pH of approximately 6.6–6.7 and tends to diminish if the pH is either increased or decreased. Concentrated milk plasma has the greatest amount of water bound at a pH 6.2–6.4 and tends to diminish if the pH is either increased or decreased.

The bound water content per unit of casein tends to diminish with the concentration of the casein sol. Raising the heating temperature lowered the bound water content of the concentrated milk plasma. High pasteurization temperatures decrease the bound water content of the fat globule "membrane" and of pure milk phospholipids.

Pasteurization of cream at 143° F. for 30 minutes decreases only slightly the bound water content while homogenization decreases the bound water content still further. Homogenization decreases the bound water content of "ice cream mixes." The higher the pressure of homogenization the greater was the reduction of bound water content. Destruction of the clumps by dual homogenization increases the stability of the proteins and increases the amount of bound water.

The freezing of skimmilk and condensed skimmilk over long periods of time reduces the protein stability and the bound water content.

The so-called milk stabilizing salts tend to increase slightly the bound water content and protein stability of concentrated milk plasma and cream,

while the destabilizing salts tend to decrease the bound water content and protein stability of concentrated milk plasma and cream.

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VOLUME XXI JULY, 1938 NUMBER 7

JOURNAL OF DAIRY SCIENCE

Published by the
AMERICAN DAIRY SCIENCE ASSOCIATION
R. B. STOLTZ
Ohio State University, Columbus, Ohio, Sec.-Treas.

ABSTRACTS OF LITERATURE

A. C. DAHLBERG, Editor
Geneva, New York

MILK AND MILK PRODUCTS

Published in cooperation with
INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS
R. C. HIBBEN, 1105 Barr Bldg., Washington, D. C., Exec. Sec.

INTERNATIONAL ASSOCIATION OF MILK DEALERS
R. E. LITTLE, 309 W. Jackson Blvd., Chicago, Illinois, Exec. Sec.

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SPECIAL PUBLICATIONS

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Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

CHEMISTRY

267. A New Method for the Determination of Butterfat in Dairy Products. JOHN GOLDING. J. Dairy Research 8, p. 275, 1937.

A simple gravimetric method suitable for the determination of fat in cream, ice cream mix, milk, and possibly other dairy products is described. The fat is separated by churning following the addition of a variable quantity, dependent on the product being tested, of a reagent consisting of 75 ml. of C. P. ammonium hydroxide, 35 ml. of n-butyl alcohol, and 15 ml. of 95 per cent ethyl alcohol. The butter is washed with water and then removed to a metal dish for frying. The percentage of fat is calculated from the weight of dried fat and the weight of the original sample. Results were found to agree with the Roese-Gottlieb analysis within $\pm$ 0.05 per cwt.

S.T.C.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

Abstracts of interest are numbers 267 and 271.

DISEASES

268. Bovine Mastitis. III. A Comparison of the Bacteriological Reactions of Normal and Mastitis Milk from Young Cows. RALPH B. LITTLE, The Rockefeller Inst. for Med. Research, Princeton, N. J. Cornell Veterinarian 28, 1, p. 23, Jan., 1938.

The milk from eight first calf heifers was examined before and after their udders were infected with a double zone hemolytic streptococcus. The methods used were daily examinations of chlorine, leucocyte count, bacteriological examination of the milk, and pH values. After the onset of subclinical mastitis in these eight animals, 2163 daily examinations of the fore milk showed that the bacteriological plating of the milk in blood agar was more efficient in the detection of infection than any other method employed for typical hemolytic streptococci were observed in the milk of every examination. The next more reliable test was the direct leucocyte count; in 94 per cent of the examinations the count per cc. of milk was between 300,000 and 10,000,000 cells or over.

L.A.M.

269. Detection of Mastitis by the Bromthymol Blue Test, Leucocyte Count, and the Microscopic Examination of Incubated Milk. A. C. FAY, H. W. CAVE AND F. W. ATKESON, Kan. Agr. Exp. Sta., Manhattan, Kan. Cornell Veterinarian 28, 1, p. 40, Jan., 1938.

On a basis of routine examination of individual quarter samples of milk from 114 cows in the college herd the animals were segregated into three

principal classes: Class A, 70 animals regarded as free from mastitis; Class B, 17 head regarded as suspicious for mastitis because of high leucocyte count (500,000 or more per cc.) in the milk from one or more quarters; Class C, 27 head, regarded as positive for mastitis because of presence of long chained streptococci in samples incubated 16 hours and usually though not necessarily a high leucocyte count. The results of the studies showed that although the Bromthymol Blue test rarely gives a false reaction with a known negative cow, it fails to detect a sufficiently high percentage of the opposite cows to recommend it as a sole means of identification of mastitis for segregation purposes. The fact that high leucocyte counts above the arbitrary standard of 500,000 per cc. were found in 36.7 per cent of the samples containing long chained streptococci suggests that the standard is too high for proper interpretation. Leucocyte counts above 100,000 per cc. and the appearance of streptococci in incubated samples of milk in chains of only medium length frequently gave fore warning of impending mastitis. It was found inadvisable to move a cow from an infected group to the non-infected group because of a few negative tests. L.A.M.

270. Infectious Bovine Mastitis. 5. Bovine Mastitis and Milk Yield. G. C. White, E. O. Anderson, R. E. Johnson, W. N. Plastridge, F. J. Weirether, Storrs Agr. Exp. Sta., Storrs, Conn. Bul. 220, August, 1937.

To determine the effect of mastitis on milk yield data are studied on 35 cows in the Connecticut State College dairy herd and on 22 cows in a farmer-owned herd. Since in both herds animals with acute cases were discarded, the study deals chiefly with incipient and mild forms of the disease.

Four tests are used to determine the status of animals during the various lactations, namely: identification of organisms, bromthymol blue test, leucocyte count, and sediment test.

Lactations covering 240 days corrected to full age and to three time milking for the college herd and two time milking for the farmer's herd, are used to compare production before and after reaction. In the college herd a loss of 679 pounds of milk or 6.5% and in the farmer's herd, of 559 pounds of milk or 5.7% resulted from infection. The amount of loss increased with the number of quarters affected, reaching 1134 pounds or 12.0% and 1111 pounds or 11.2% respectively in the college and the farmer's herd, when all four quarters reacted positively.

Individual lactation period curves covering four or more lactations are shown for five animals and compared with the normal expected production curve.

About three-fourths of all animals show a loss in yield following reaction. Some individuals may pass through several lactations before yield is drastically reduced, or the milk becomes abnormal in appearance; some show a

loss for one or two lactations, and then recover in yield; others suffer a drastic loss in yield and may continually produce abnormal appearing milk. The evidence shows no shortening of the lactation period.

No evidence was found to indicate that mastitis decreases the percentage of fat in the milk, the average tests being 4.16 before and 4.15 following reaction. A.I.M.

FEEDS AND FEEDING

271. The Relative Values of Raw and Pasteurized Milk in the Feeding of Calves. J. WILKIE, S. J. EDWARDS, A. B. FOWLER AND N. C. WRIGHT. J. Dairy Research *8*, p. 311, 1937.

Bull calves from tuberculin-tested Ayrshire herds were fed on raw or commercially pasteurized milk up to 12 weeks of age, in amounts in relation to their body weights. This diet was supplemented from the eighth week by hay at the rate of 2/3 pound per head per day. The milk used was mixed milk from untested herds, the raw and pasteurized milk being derived from the same bulk samples.

No significant differences were noted in gain in live weight or in skeletal growth. Marks awarded by experimental stock judges showed consistent differences in favor of the pasteurized milk-fed group.

Inoculations of grouped daily aliquots of raw milk twice weekly into duplicate guinea-pigs resulted in finding viable tubercle bacilli in 70 per cent of the samples and *Brucella abortus* in 38 per cent of them. The pasteurized milk samples were uniformly negative to both tests. The differences in tuberculous infection of the two types of milk were reflected in the results of tuberculin tests and post-mortem examinations on the calves. Twenty-four out of thirty-six calves fed on raw milk reacted to the test. One calf in the pasteurized milk-fed group reacted to the test, but post-mortem examination and inoculation of glandular material into guinea-pigs failed to confirm the presence of any tuberculosis. S.T.C.

272. Further Studies on the Influence of Green Fodder, Silage and Hay on the Metabolism of Ruminants. FRITZ SCHNEPF, Tierzuchtinstitut der Albertus-Universität Königsberg. Biedermann's Zentralblatt, Abteilung B: Tierernahrung. *9*, 3, p. 191, 1937.

These studies were planned to determine (1) the relationship between Ca metabolism and pH of the urine on one hand, and CO_2 tension of the blood plasma and pH of the blood on the other hand, and (2) the effect on the animal body of green feeds preserved in different ways.

Wethers were fed a mixture of second cutting red clover and timothy as green plants, as hay, and as silage. The hay was dried on racks. To the silage was added as a preservative for each 100 kg. of green crop (1) ten acid equivalents of HCl, (2) ten acid equivalents of H_2SO_4, (3) one per cent of sugar.

Results indicate that:

(1) CO_2 tension is as good a criterion of the potential alkalinity or acidity of a feed as is the Ca metabolism; the pH of the blood is too constant to be of any value for indicating small differences; the pH of the urine is influenced markedly by the nature of the ration, but individual differences are often greater than species differences.

(2) Hay has a stronger basic effect than green plants.

(3) Silage preserved with sugar has about the same effect on acid-alkali balance in the body as hay or green plants.

(4) Silage preserved with HCl or H_2SO_4 exerts a distinctly negative effect on Ca metabolism and the blood picture.

(5) If about one-fourth of the dry matter is in the form of hay, sometimes restoration of balance is noted, but it is not enough to compensate the total effect of the mineral acids. J.G.A.

273. Utilization Experiments on Ruminants with Artificially Dried, Chopped Protein-Rich Green Fodders. G. Frölich und F. Haring, Institut für Tierzucht und Molkereiweisen der Martin-Luther-Universität Halle a.S. Biedermann's Zentralblatt, Abteilung B. Tierernahrung. *9*, 3, p. 204, 1937.

Digestibility by wethers of the nutrients of three dried products prepared from green alfalfa and from vetch mixture (so-called Landsberg mixture) by the Rema Rosin drying method, is reported.

Digestibility of artificially dried green alfalfa was improved by grinding as compared with chopping. The chopped vetch mixture was somewhat more digestible than the dried alfalfa. The following values are reported:

Digestible crude protein—in alfalfa meal, 10.83%; in chopped alfalfa, 10.35%; in chopped vetch, 10.17%; starch values—29.33, 26.90, and 38.52% respectively. J.G.A.

274. Significance of Cod Liver Oil in Calf Feeding. Lauri Paloheimo, Institut für Haustierlehre der Universität Helsinki. Biedermann's Zentralblatt, Abteilung B. Tierernährung. *9*, 3, p. 234, 1937.

In an earlier paper (this journal, *9*, 52) an account was given of work in which Ayrshire calves were reared with small quantities of whole milk, their requirements for fat-soluble vitamins being supplied by addition of cod liver oil.

The work has been continued, cod liver oil being omitted, other conditions being the same as already noted. Maximum gains during the first few months were not striven for but the calves were well cared for, and were in good health throughout. Indigestion was specially guarded against.

Under these conditions, even when the total quantity of whole milk was limited to 10–15 kg., calves seemed to thrive nearly as well as when 5–10

grams of cod liver oil were fed daily. The dams, with two exceptions, had received feeds rich in vitamins during the latter part of the gestation period. But the two exceptions indicate (but two calves are too few to prove) that this preparatory feeding of the dams is not absolutely necessary for thrifty calves, even if these are reared with very little whole milk and without cod liver oil. J.G.A.

275. Studies on the Influence of Air Tight Covers on the Preservation and Value of Silage. KURT DIETRICH, Tierzucht-Institut der Albertus Universität Königsberg. Biedermann's Zentralblatt, Abteilung B: Tierernährung. *9,* 3, p. 255, 1937.

Glass cylinders were filled with chopped clover or marrow stem cabbage. To one lot no preservative was added; others had sugar or sulfuric acid added. The cylinders were closed with rubber stoppers each provided with a fermentation tube. A parallel series were sealed with a layer of loam. Larger scale trials were conducted in Aurich fermentation vessels of 1 cubic meter capacity, or in Tschechnitz fermentation chambers.

Conclusions reached were:

1. Complete exclusion of air hinders fermentation, as indicated by high pH values, very little lactic acid formation, a large amount of combined acetic acid, and formation of a small amount of butyric acid.
2. Wilting before ensiling still further slows up the process with clover; with m.s. cabbage more compact storage and corresponding improvement in the silage was noted.
3. Sugar favorably affects the ensiling of fresh plants as well as of wilted ones.
4. Chopping effected an improvement in all cases.
5. Addition of CO_2 has a favorable effect, but this is small in comparison with the effect of sealing the chamber with a layer of loam.
6. Addition of mineral acids checks the formation of CO_2 almost completely.
7. Comparison of the silage from air tight vessels with that from similar vessels covered with a layer of loam indicates that in all cases the upper layers were superior when the latter method was used.
8. There were no considerable differences in protein degradation in the several lots.
9. Digestion trials (wethers) do not indicate any superiority of one method over another. J.G.A.

HERD MANAGEMENT

276. Biometrical Study of the Production Improvement in a British Friesian Herd. HANS LÖRTSCHER, Zeitschr. Züchtung. Reihe B. Tierzücht. u. Züchtungsbiol. *39*, 3, p. 257, 23 fig., 1937.

The milk production records from 1906 to 1932 in a large Friesian herd in England were studied to measure the non-hereditary factors influencing milk yield and to find ways to correct for those factors when studying inheritance or making selections. About 4000 lactations from some 1200 cows were included. A multiple regression equation and nomogram were developed for standardizing the test-year records for age of the cow when the test year began, for length of the dry period, for length of the service period, and for the inter-relations between these factors. The length of the preceding dry period was of slight importance unless it was shorter than three weeks. The month of calving, the sex of the calf, and whether it was a twin or a single birth had little effect. Expressing each individual yield relative to the herd average for the same year (the "Stalldurchschnitt" method of Peters, v. Patow, Krüger, and others) was studied as a means of correcting for intangible environmental factors such as weather, changes in feeding policy, etc. Complete reliance on these relative figures would imply that all year-to-year differences in the herd average are of environmental origin. On the contrary the author finds that in his material many of the differences in the yearly averages resulted from changes in the average genetic composition of the herd. This conclusion is based on the steadiness of the trends and on comparing the year-to-year changes of the herd average when only those cows which had records in both years were included, with the contemporary changes in the herd average when it included the records of all cows. In this procedure the author offers a way to use the herd average to correct for unrecorded changes in herd environment, yet without assuming that the average genetic composition of the herd is unchanging. That the method will also furnish a bridge for comparing the records of two cows in different herds unless those two herds happen to have interchanged a number of cows, is not apparent.

The author concludes that 50 to 70 per cent of the variance in the milk records with which he worked (corrected for age, dry period and service period) is genetic, but that construes as genetic nearly all of the differences in yearly averages. Those differences account for nearly 24 per cent of the total variance in individual records. Regression of individual productions on changing conditions is thought not to be entirely linear and not to follow the same course for all cows. This makes Mendelian analysis difficult, if possible at all.

This particular herd was outbred in its early history, the breeding stock coming from various other British Friesian herds; then it was outbred with stock imported from Holland; finally there was a period of breeding entirely within the herd, with linebreeding directed toward the imported animals but with efforts to avoid inbreeding while staying within the herd. The inbreeding did not become high enough to produce noticeable effects. Coefficients

of inbreeding and *inter se* relationship are presented to make the description of the breeding policy of the herd more complete and quantitative.

J.L.L.

277. Measuring Milk Producing Ability. L. Krüger. Breslau. Züchtungskunde *13*, 1, p. 2, Jan., 1938.

The author emphasizes the distinction between the milk producing *ability* of a cow and the *record* of the milk she actually produced. His method of correcting for differences in environmental circumstances is presented and its use is illustrated with a few examples. Yields are corrected to a standard interval of 360 days between calvings. The last 50 days of this interval are a dry period. Correction is also made for deviations in the length of the preceding calving interval and dry period and for age. Corrections for unrecorded environmental conditions applying to that herd are made by multiplying the record of this cow by the ratio of the standard production in that region for that system of dairying to the average production of the cows which freshened in the same herd during the six months centering around the time that this cow freshened. The inherent assumption, that the average producing ability of the group of cows freshening in those six months in that herd is equal to the average producing ability of all cows of that region, doubtless has exceptions and needs some qualifications. If those can be had, this process of correction offers an automatic way of correcting for general conditions of management and feeding, without recording what those were nor estimating the effect of each. There is, of course, need for judgment in deciding what groups of herds should be combined to provide the standard for that region and for that type of agriculture. There is also opportunity to exercise judgment in discarding records which were "abnormal" for reason of accident or distinct and unmistakable illness. J.L.L.

ICE CREAM

278. A Summary of Six Years of Research on Tallowy Flavor in Strawberry Ice Cream. C. A. Iverson, Iowa State College, Ames, Iowa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 7, Oct., 1937.

The author concludes from this study that oxidases from the fruit are not responsible for causing oxidized flavors in strawberry ice cream.

The higher the iron content of strawberry ice cream, the less oxidized flavor developed. This was thought due to the existence of ferrous iron in combination with a milk constituent, serving in this combination as an antioxidative catalyst.

Reichart-Meissl numbers and acetyl values determined on fat extracted from ice cream showed no relation to the rate of development of oxidized

flavors. The trend in the iodine number changes indicated fat oxidation during development of oxidized flavors.

Oxidized flavors developed more frequently when whole or skim condensed milk were used in mixes as compared with dry skimmilk or condensed skim or whole milk made in stainless steel pans.

The author concludes, further, from experimental evidence that the addition of fruits to ice cream actually retards the development of oxidized flavors in ice cream.

The copper content of mixes in which no oxidized flavors developed was found to be less than 1.18 p.p.m., whereas the lower limit of the copper content of ice creams which became oxidized was 1.80 p.p.m. When mixes contained copper contents between these limits and developed oxidized flavors, it was assumed that factors other than the copper content contributed to the development of the off-flavor. It is also stated that the gross quantity of copper present is not the only factor of importance, but the state in which the copper exists in the ice cream is also of significance. M.J.M.

279. Quality Through Freshness. A Discussion led by H. F. JUDKINS, National Dairy Prod. Corp., New York, N. Y. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. 2, p. 104, Oct., 1937.

(a) A. C. BITTER, Wm. Neilson, Ltd., Toronto, Can.

Packages are marked in code and each driver is equipped with a key. It is his responsibility to see that the oldest stock is sold first in the stops along his route. By limiting the number of articles and eliminating slow selling products in winter months it was possible to carry only five standard bricks and a weekly special. By so doing, fresher ice cream has been sold and sales have increased considerably.

(b) J. A. CLUTTER, Dairyland, San Antonio, Texas.

In each retail store some ice cream was set aside, held for three weeks, and then scored against the fresh product. On the average, the ice cream had deteriorated about two points in flavor score over the storage period of three weeks. If fresh high quality ingredients are used to make a desirable product, it should be marketed promptly before the ice cream deteriorates in quality.

(c) GEORGE A. KURK, Beatrice Creamery Co., Lincoln, Neb.

The necessity of selling fresh ice cream has been shown repeatedly. In order to achieve this, careful supervision of the hardening room is essential, a survey of the dealers' sales possibilities is desirable, and lastly many companies should eliminate small accounts where the daily sales are low and the ice cream deteriorates before being sold.

(d) R. J. QUIRIE, United Farmers Cooperative Creamery Assn., Charlestown, Mass.

The consumer often does not get the same high quality ice cream which is placed in the cabinet of the distributor. The answer lies in what might be called sales or service contact work which can be done by the route salesman, the territory salesman or one especially designated for the work. The distributor's stock should be checked, the mechanical and sanitary character of the cabinet should be watched and the cabinet should be operated at a sufficiently low temperature for packaged goods.

(e) J. Frank Ward, Midwestern Dairy Products, Salt Lake City, Utah.

Much of the trouble with off-flavors is due to the use of inferior products as well as the failure to market ice cream promptly. Both factors must be watched.

The operation of retail ice cream stores by ice cream manufacturers has done much to teach the manufacturer the kind of ice cream the public prefers.

Summary by Mr. Judkins

Data were presented to show the variance in rate of turnover for one dealer as compared to another. Bulk sales varied from 2 to 39 gallons per gallon of inventory for the period of October 1 to April 1, 1934. The variation in sales of brick ice cream was given for the same period, as well as the distribution of products stocked in the cabinets. From this information the following recommendations were made:

1. The sales department should study the relation of sales volume to flavors of bulk and package goods carried.
2. Brick package units such as one-half gallon units, should be kept in the cabinet properly.
3. Drivers should be instructed regarding the proper use of these units and should educate the dealers how to use them. M.J.M.

280. The Statistical and Accounting Bureau. O'Neal M. Johnson, Intern. Assoc. Ice Cream Mfgrs., Washington, D. C. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 7, Oct., 1937.

During the year the Statistical and Accounting Bureau released three bulletins on taxation. The Association Accounting system was installed in a considerable number of plants. Other activities of the bureau included a report of the survey of the retail store, the advertising analysis and the analysis of ice cream sales, and the ice cream sales index for 1936. Preliminary reports of sales in 1937 have also been released. M.J.M.

281. The Accountant Looks Toward 1938. J. S. Bloom, Abbotts Dairies, Inc., Philadelphia, Pa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 10, Oct., 1937.

It is the accountant's job to ascertain the trend in cost of raw products, manufacturing and labor costs, taxes, sales, new demands in sanitation and the trend in other costs as well. It is necessary to chart the course of busi-

ness if comptrollers and accountants are to serve the best purposes of the industry. M.J.M.

282. Controlling Advertising Costs. K. R. LEACH, Dairymen's League, Inc., Syracuse, N. Y. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 16, Oct., 1937.

The proper control of advertising costs depends upon:

1. The setup of a budget and advertising plant at the beginning of the year.
2. The adherence to this budget and plan during the year.
3. The constant checking of the effectiveness of advertising both from an expense and a result point of view.
4. Proper checking of expenditures as to accuracy of charges made against the advertising account.
5. A preparation of analysis for study by management to enable management to plan its future advertising programs.

These five things should form a basis for proper control of advertising and should increase the effectiveness of the advertising. M.J.M.

283. Controlling Selling Costs. H. W. BRIGHAM, Teall's Ice Cream Co., Rochester, N. Y. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 22, Oct., 1937.

The control of selling costs is more or less controlled by the policy set by the management. It is possible in the larger company with a large sales force to consolidate territories and thus save expense. However, the company with three or four men traveling finds it almost impossible to vary the budget for sales expenses without altering the effectiveness of the work. M.J.M.

284. Controlling Trucking Costs. H. W. SCHYELKE, Southwest Ice and Dairy Products, Oklahoma City, Okla. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 30, Oct., 1937.

Selling and delivery expenses in many businesses have been steadily mounting. The qualifications of the driver salesman affect the trucking costs on his route. The type of delivery service and the kind of delivery equipment enter materially into determining trucking costs. Telephone expenses and special delivery service often are allowed to increase costs unnecessarily.

The truck salesman should keep a detailed expense account and the adherence to this record keeping often helps to show him the necessity to keep costs lower when possible. M.J.M.

285. Controlling Cabinet Costs. J. E. SHIPLEY, Abbotts Dairies, Inc., Philadelphia, Pa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 34, Oct., 1937.

By keeping simple monthly accounts of cabinet service work done, repair shop overhead, truck costs, and expenditures for materials, it is easy to determine cabinet service costs. With this information it is possible to decide whether it would be cheaper to hire an outside cabinet service contractor. The data should also show whether it is cheaper to rebuild or to buy new equipment; or if repairs increase, the real cause of the increase can be determined. The need for having adequate records so that the causes for changes in costs can be determined is imperative. M.J.M.

286. What Management May Expect from the Association Accounting System. C. A. Armitage, United Farmers' Coop. Creamery Assn., Charlestown, Mass. Proc. 37th Ann. Conv. Int. Assn. of Ice Cream Mfgrs. *3*, p. 42, Oct., 1937.

There are many services one should expect from the association's accounting system. It should show when new equipment should be bought, what the operating costs should be, and what savings should be made. The system shows fluctuations in expenses and furnishes a basis for the investigation of these expenses. Such a study should be made at regular intervals. The system provides a basis for determining the costs of products and production and in this way makes it possible to ascertain the necessary selling price for each item. By showing which items are most profitable the accounting system shows which products to feature.

Intelligent merchandising is impossible without knowing unit costs for each product made. The association accounting system furnishes this information. M.J.M.

287. Proved System Short Cuts. O'Neal M. Johnson, Intern. Assoc. Ice Cream Mfgrs., Washington, D. C. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 47, Oct., 1937.

A number of changes and additions to the Association Accounting System which have increased the effectiveness of the system were explained. This was followed by a discussion of problems and suggestions pertaining to accounting. M.J.M.

288. Cutting Office Costs. J. S. Bloom, Abbotts Dairies, Inc., Philadelphia, Pa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *3*, p. 65, Oct., 1937.

Since the main expense in office costs is labor, the main problem in controlling the costs is to study labor costs. There are different grades of labor to be done in an office and a person trained and fitted for each grade should be employed. A program of work should be planned for each person in the office.

Other important considerations are to have the necessary mechanical appliances for most efficient work from the employees of the office, and the

office should be so organized that the flow of work from person to person is accomplished efficiently. M.J.M.

289. Late Developments in Hardening Room Installations: Bay Type of Vertical Coils. RIDGWAY KENNEDY, JR., Abbotts Dairies, Inc., Philadelphia, Pa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 20, Oct., 1937.

The ammonia coils used in the hardening room were installed in a vertical position in bays or bins and the ice cream was stacked in the bays. A coil unit was developed which could be fabricated and welded at the factory. Each bay was of the same size and 175, 2½ gallon cans were stacked in each bay. The article contains photographs and figures and complete instructions for the construction of this type of hardening room.

There are several advantages of the bay type of installation. Defrosting proved unnecessary because the frost was shaken or rubbed off the coils by piling the cans of ice cream against the coils. The amount of pipe in the room was reduced from forty thousand feet of two-inch pipe to twenty-five thousand feet of one and a quarter inch pipe. The refrigeration is utilized more efficiently. Less difficulty from ammonia leaks has been experienced. M.J.M.

290. Problems in Meeting Bacterial Standards for Ice Cream. H. MACY, Univ. of Minnesota, St. Paul, Minn. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 36, Oct., 1937.

Sanitary codes adopted by most states have bacterial standards which range between 100,000 and 500,000 per millileter. However, certain cities have adopted maximum bacterial standards as low as 25,000 per millileter. Considerable vigilance is necessary to meet such exacting requirements.

The problems of meeting bacterial standards involves three issues, namely, the procurement of high quality ingredients, the effective pasteurization of the mix, and the maintenance of proper sanitary conditions within the plant at all times. When these issues are satisfactorily met, the most exacting standards may be regularly observed.

An efficient laboratory service is essential if bacterial counts are to be controlled successfully. Constant checking of materials, plant processes and sanitary measures is essential. If the cost of such service seems prohibitive for the smaller companies, thought should be given to the formation of cooperative laboratory service. M.J.M.

291. Proper Butterfat Differentials between Fruit and Vanilla Ice Cream. CARL KOERVER, The Borden Co., Brooklyn, N. Y., AND HAROLD PRATT, Philadelphia Dairy Prod. Co., Philadelphia, Pa. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 43, Oct., 1937.

Fat differentials between fruit and vanilla ice creams for the various states are given. In the majority of instances a differential of 2 per cent in fat content is allowable. In order to comply with the standards and, at the same time, use a high percentage of fruit many companies are forced to prepare a special mix for fruit ice cream.

As high as 32 per cent fruit has been used in making certain fruit ice creams. Starting with a 12 per cent mix, the fat content of the resulting ice cream would be 8.16 per cent. The reduction in fat is nearly double the differential allowed by law in many states.

Many states also have standards for total milk solids. Two states permit no reduction of the milk solids for fruit or nut ice cream; the balance permit a reduction of 2 to 5 per cent. Using 30 per cent fruit, a reduction of 6 per cent milk solids should be permitted.

The authors favor a differential between vanilla and fruit ice creams in state standards of 4 per cent fat and 6 per cent total milk solids. They urge that individual manufacturers, as well as associations see that their interests are properly protected by advocating sound regulations. M.J.M.

292. A Simplified Solids Tester for Ice Cream Mix. Kenneth M. Renner, Texas Tech. College, Lubbock, Texas. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 52, Oct., 1937.

A method is described and the necessary equipment is listed for a simplified solids tester for ice cream mix. The cost of the equipment, exclusive of a Torsion Balance Moisture Scale, is approximately 12 dollars. Results given indicate that the method checks within 0.25 per cent of the Mojonnier test in every instance where comparisons were made. When used with plain condensed skim milk, results similar to those with ice cream mix were secured, but with evaporated milk the results averaged 0.15 per cent higher than the Mojonnier method. M.J.M.

293. Consumer Preference: (a) A Study of Ice Cream Types. P. H. Tracy, Univ. of Illinois, Urbana, Ill. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 60, Oct., 1937.

The following conclusions were drawn from a large number of consumer-tasting tests of ice cream:

1. Body and texture are very important factors in influencing consumer preference for ice cream. Consumers preferred an ice cream having a smooth body and texture.
2. The flavor of a medium fat ice cream was preferred to that of a high fat content.
3. The high serum solids ice cream was preferred to the medium serum solids ice cream.
4. Approximately 25 per cent of the testers preferred a homemade type of ice cream to the regular commercial type of ice cream.

5. From the standpoint of this test a stabilizer is a desirable constituent of ice cream.

6. Ice cream containing a medium yellow color was preferred to uncolored ice cream.

7. The preference for vanillas varied greatly.

8. The medium and high sugar content ice cream was preferred to a low sugar content ice cream.

9. A greater percentage of women than men showed a preference for ice cream with a pronounced flavor and a heavy body. M.J.M.

294. Consumer Preference: (b) Effect of Serving Temperature. W. H. E. Reid, Univ. of Missouri, Columbia, Mo. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 72, Oct., 1937.

The results of this investigation indicate that the serving temperature is a factor of considerable importance in determining consumer acceptance of ice cream and sherbets. Dipping properties and the stability of the products studied are also affected by the serving temperature.

The most desirable temperature for serving most ice cream and sherbets was 10° F. However products with mild flavors or a low sugar content were preferred at a higher temperature than 10° F. and those with strong flavors or high sugar content were more acceptable at temperatures below 10° F. The flavor became more pronounced in all ice creams and sherbets as the temperature was increased from 6° F. to 18° F.

The body of both ice cream and sherbets was termed too resistant at 6° F. Sherbets were criticized at 14° F. or higher as being soggy and lacking in resistance. The same criticism was made of ice creams served at 18° F.

M.J.M.

295. Sanitary Factors at the Fountain other than Ice Cream. F. W. Fabian, Michigan State College, East Lansing, Mich. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2*, p. 90, Oct., 1937.

A survey was made of twenty-one drug stores and twenty-nine restaurants and dairy bars in an attempt to study from a bacteriological viewpoint each item entering into the serving of ice cream.

The work indicates that there should be a bacterial standard for dipper water and that a satisfactory standard would be the same as the maximum permissible bacterial count allowed for ice cream.

Of the flavors and syrups tested, chocolate syrup usually was the heaviest contaminated and contributed the most bacteria to a dish of ice cream. Strawberry, cherry, pineapple, peach, butterscotch, lemon and orange syrups were sources of contamination, they are listed in the order of the average bacterial content. A bacterial standard of 5,000 bacteria per cc. is proposed for the flavoring and fruit syrups used with ice cream.

Unless proper precautions are observed, ice cream can be grossly contaminated during serving. Dipper water contamination usually is greater

than that from chocolate and fruit syrups. Spoon and dish contamination are negligible if they are washed in soapy wash water at 110 to 120° F. containing less than 50,000 bacteria per cc., then rinsed in water at 170° F. for at least a minute or for a minute or longer in clean water containing 50 to 200 p.p.m. of available chlorine.

Forty-six per cent of the ice cream sold in Lansing and East Lansing, Michigan, was found to exceed the legal bacterial standards of 150,000 bacteria per cc. M.J.M.

296. A Cooperative Quality Improvement Program. E. H. PARFITT, Purdue Univ., Lafayette, Ind. Proc. 37th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs. *2,* p. 100, Oct., 1937.

The quality improvement program sponsored by Purdue University for Indiana ice cream manufacturers was presented. The results of the analysis and scoring of ice cream samples was given in tabular form. The success of the project is indicated by the increased number of commercial samples submitted each year. M.J.M.

297. Best Selling Flavors. Ice Cream Trade J. *34,* 1, p. 9, Jan., 1938.

Information collected by Esmund, Gundlach and Co., Cincinnati, Ohio, from large and small manufacturers located in all parts of the United States and Canada, indicated that the 12 most popular flavors of ice cream were vanilla, strawberry, chocolate, cherry, maple nut, orange pineapple, butter pecan, black walnut, banana, peach, lemon, and pineapple. Next to the above came chocolate variations, fruit salad, almond toffee, butterscotch, peppermint stick, tutti fruitti, caramel, and pecan krunch. Sherbets were rated as follows: orange, pineapple, raspberry, lemon, and lime. W.H.M.

298. The Year's Research Record. J. C. HENING, New York Agr. Exp. Sta., Geneva, N. Y. Ice Cream Trade J. *34,* 1, p. 24, Jan., 1938.

Subjects discussed briefly are: homogenization by sonic vibration, a new vacuum method of freezing fresh milk and cream for use in ice cream, problems encountered in making ice cream of a high butterfat content, the use of cerelose in ice cream, comparison of different serum solids concentrates for ice cream, sodium alginate as a stabilizer for ices, *E. coli* as an index of pasteurization efficiency, sanitary procedure for handling ingredients added to the mix after pasteurization. W.H.M.

299. How to Figure Mix Costs. E. L. REICHART, The Univ. of Nebraska, Lincoln, Nebr. Ice Cream Trade J. *34,* 2, p. 22, Feb., 1938.

The cost of ice cream mix varies greatly depending upon the cost and availability of the various ingredients used and upon the composition of the mix. Generally a plant with an output of less than 20,000 gallons annually is better off to buy mix. In territories where fresh products are available,

mixes can be best and cheapest made using milk, cream and condensed skim as sources of fat and serum solids. In localities removed from actual production areas, mixes are cheapest when made from butter, skimmilk powder or other concentrates. W.H.M.

300. Sales Increase 300 Per Cent. Lucious S. Flint. Ice Cream Trade J. *34*, 2, p. 12, Feb., 1938.

Details are given for a sales campaign used by Edy's Grand Ice Cream Company, Oakland, California, which has materially increased the amount of ice cream sold to their dealers. The plan is built around a monthly feature special and the use of point-of-sale display material. Carefully worked out receipts are furnished the dealers and a great deal of personal contact work is done to assure the success of the campaign. W.H.M.

Other abstracts of interest are numbers 267, 271, and 303.

MILK

301. Bitterness and Thinning in Canned Cream. A. A. Nichols, G. R. Howat and C. J. Jackson. J. Dairy Research 8, p. 346, 1937.

Three organisms, all strains of *Bacillus subtilus,* were isolated from defective commercially-canned cream which, on inoculation into normal cream, caused bitterness and thinning. Some thirty-six strains of *B. subtilus* were isolated from canned dairy products but only a few were capable of producing the defects when inoculated into normal cream. The spores of these organisms were found capable of withstanding temperatures up to 120° C. for as long as 40 minutes. The defects developed more rapidly by incubation at 37° C. than at lower temperatures. Determinations of the non-protein nitrogen and of the peptone and sub-peptone fractions indicated that the development of both bitterness and thinning were related to the breakdown of the protein. Owing to the high thermal death point of the organisms responsible for the defects, it was expected that control under commercial conditions must depend more on improving the quality of the incoming milk supply than on altering the conditions of sterilization of the canned product. S.T.C.

302. Soft Curd Milk of the Mineral Modified Type. Anonymous. Milk Dealer *27*, 6, p. 43, March, 1938.

A brief description of soft-curd milk of the Mineral modified type and its sale in Chicago. C.J.B.

303. The Problem of Recontamination of Pasteurized Milk and Its Products. L. C. Bulmer, Bureau of Food and Dairy Inspection, Jefferson Co. Bd. of Health, Birmingham, Ala. Milk Dealer *27*, 6, p. 76, March, 1938.

Based on a study of conditions which prevail in all the 51 major cities of America, with population over 200,000, this paper deals not only with the vexed problem of the promiscuous handling of pasteurized milk and ice-cream mix, but also the relationship between boards of health and industry at the present time.

The author also points out that Birmingham is the only city in America that has regulations which adequately control this problem. C.J.B.

304. Sweet Acidophilus Milk. Anonymous. Milk Dealer *27*, 6, p. 116, March, 1938.

A description of how sweet acidophilus milk can be made in your own plant with no added equipment and at a marked reduction in cost to the consumer. C.J.B.

305. Uniformity of Cream Line. Joseph Burns, Capitol Dairy, Madison, Wis. Milk Dealer *27*, 6, p. 120, March, 1938.

A brief discussion of the importance from a sales standpoint of having a uniform cream line.

The author suggests observation of the following points in order to maintain a uniform cream line.

1. Have definite routine production.
2. Never heat milk above 145° (excepting in flash system).
3. Avoid use of live steam in pasteurizing jackets as much as possible.
4. Have sufficient refrigerating capacity so that milk need not be cooled by water in pasteurizer jacket prior to sending over surface cooler.
5. Avoid excess agitation during holding period and in storage tanks.
6. Avoid holding periods over 30 minutes.
7. Have thermometer in water jacket of pasteurizer so that if heating by hot water, the temperature of the heating medium can be available (usually about 160° to 175°). C.J.B.

Other abstracts of interest are numbers 267, 268, 269, 270, and 271.

PHYSIOLOGY

306. The Immature Rat Uterus as an Assay Endpoint for Gonadotropic Substances. C. G. Heller, Henry Lauson and E. L. Severinghaus. Dept. of Medicine, Univ. of Wisconsin, Madison. Amer. J. Physiol. *121*, 2, p. 364, Feb., 1938.

Two hundred and twenty-eight immature female rats were used. The minimal dose producing uterine enlargement (as judged by gross inspection) and uterine weight increases were only one-eighth as large as the minimal dose which resulted in ovary weight increase. The curves rise rapidly to a maximum and very slowly recede, so that only a small portion, at the lowest dose levels, is useful for assay purposes. These workers found that the ovary actually decreased in weight at first as the result of gonado-

tropic stimulation while with larger doses it responds both by increased secretion and growth. An addendum to the paper states that on recalculation of the data of Levin and Tyndale a ratio of 3 or 4 to 1 is obtained, as contrasted to their ratio of 8 to 1. D.L.E.

307. Changes in the Water of Tissues Induced by Diets Containing Various Mineral Supplements. E. S. Eppright and A. H. Smith, Lab. of Physiological Chemistry, Yale Univ. School of Medicine, New Haven. Amer. J. Physiol. *121*, 2, p. 379, Feb., 1938.

The electrolyte balance of the diet influences the hydration of the tissues. When sodium chloride constitutes the only mineral supplement to the salt-poor basal diet of rats, the tissues, except skeletal muscles, are more hydrated than normal. Potassium exerts a slightly modifying effect. When the mineral supplement consists mainly of calcium, the general tendency is toward dehydration.

The normal distribution of water in the organism depends to a considerable extent upon the balance of the calcium with its related elements and the alkali metals sodium and potassium. In the absence of calcium and phosphorus, muscle tissue contains more sodium than can be accounted for by that in the extracellular water as calculated from the chloride present.

D.L.E.

308. The Nature of Magnesium Tetany. D. M. Greenberg and E. V. Tufts, Division of Biochemistry, Univ. of California Medical School, Berkeley. Amer. J. Physiol. *121*, 2, p. 416, Feb., 1938.

A study has been made on the influence of a number of factors on the incidence, time of onset, and duration of peripheral vasodilation and hyperirritability in magnesium deficient rats. These symptoms were found to be greatly affected by the degree of magnesium deficiency, the starting age of the rats, and the dietary levels of calcium and vitamin G. At levels of less than 1 mgm. of Mg per 100 grams of food all experimental animals reacted within 10 to 14 days and their total life span was from 21 to 30 days with death resulting from a spontaneous convulsion. Probably the explanation of the apparent synergism of the two deficiencies lies in the fact that vitamin G deficiency itself promoted some damage to the nervous system which would tend to increase its reactivity so that the effects of the two deficiencies are additive. The hissing of an air blast appeared to be peculiarly effective in producing convulsions in hyperirritable individuals.

The localization of the lesion concerned with magnesium hyperirritability appears to be in the midbrain or pons as contrasted with thyroid or low calcium tetany, with which, lesions are more likely located in the neuromuscular junction. At least magnesium tetany differs from calcium tetany in that curare does not prevent the onset of convulsive seizures in this condition.

A later paper of this series (*ibid.*, p. 424) describes the effect of renal insufficiency upon the kidneys. D.L.E.

309. The Influence of Calcium and Potassium upon Intestinal Absorption. J. W. Gardner and G. E. Burget, Dept. of Physiology, Univ. of Oregon Medical School. Amer. J. Physiol. *121*, 2, p. 475, Feb., 1938.

Potassium chloride added to a 10 per cent glucose solution in concentrations from 0.03 per cent to 0.15 per cent increases the rate of absorption of the sugar solution from chronic closed intestinal loops in dogs; in similar concentrations $CaCl_2$ decreases the rate of absorption below normal. The increase produced by a 0.1 per cent solution of KCl is approximately equal to the decrease brought about by a similar concentration of $CaCl_2$. The favorable action of KCl reaches a maximum at about 0.08 per cent under these conditions. The retarding action of $CaCl_2$ increases steadily up to 0.15 per cent which was the highest concentration used. Similar results were obtained with rats by a slightly different technique. The authors state "if these results may be explained by alteration of cell permeability by the two electrolytes, our work conforms to the well established effects of K and Ca ions on cell permeability." D.L.E.

310. Enterocrinin, a Hormone Which Excites the Glands of the Small Intestine. E. S. Nasset, Dept. of Vital Economics, Univ. of Rochester, Rochester, New York. Amer. J. Physiol. *121*, 2, p. 481, Feb., 1938.

Enterocrinin is the name given to an intestinal hormone, not previously described, which plays an important rôle in the secretion of succus entericus. This hormone is obtainable from the small and large intestines of several species of animals. The small gut of the dog and the cow have the highest titre of the animals examined.

The secretagogue activity of crude extracts of these organs is not directly related to blood pressure changes because vasodilation-free enterocrinin has been prepared. Enterocrinin does not excite the pancreas; hence, it is separate and distinct from secretin. It augments the secretion of enzymes as well as fluid, a property usually not ascribed to secretin. D.L.E.

311. The Effects of Hypophysectomy and of Anterior Pituitary Extracts in the Disposition of Fed Carbohydrates in Rats. Jane A. Russell, Institute of Experimental Biology, Univ. of California, Berkeley. Amer. J. Physiol. *121*, 3, p. 755, March, 1938.

In the hypophysectomized rats, the proportion of absorbed glucose oxidized and the proportion of total calories obtained from carbohydrate were both much higher than in the normal rats. Decreases in the amount of

glycogen stored were accounted for by the increases in the rate of oxidation of carbohydrate. It was concluded that the anterior pituitary is concerned not only with preservation of body carbohydrate during fasting, but also with the disposition of this substance when it is fed. D.L.E.

312. Further Studies of Intestinal Absorption with the Performance of Osmotic Work. RAYMOND C. INGRAHAM AND MAURICE B. VISSCHER, Dept. of Physiology, Univ. of Illinois, Chicago, and Univ. of Minnesota, Minneapolis. Amer. J. Physiol. *121,* 3, p. 771, March, 1938.

The authors present a unique theory to explain the different rates of absorption of univalent and polyvalent ions from the intestine. In the presence of poly-univalent salts ($MgCl_2$, $CaCl_2$ and others) and poly-polyvalent salts ($MgSO_4$, $CaSO_4$ and others) uni-univalent salts (such as NaCl) are rapidly absorbed from the intestine against blood plasma concentration gradients as much as 28 to 1 and 10 to 1 respectively. A slow absorption of the polyvalent ions occurs at the same time. While univalent anion impoverishment is occurring in the intestine the pH of the gut fluid invariably becomes more acid, around pH 6.1 to 6.3, while with univalent cation impoverishment the gut fluid becomes more alkaline, reaching pH 7.9.

Without exception ammonia production increases in the gut during this univalent impoverishment. The concentration of NH_3-N in the gut fluid increases to as much as two hundred and fifty times its concentration in the blood. The fact that intravenous injection of ammonium salts produces a very large increase in the NH_3-N content of the gut indicates that the ammonia in the intestinal fluid is of metabolic and not of bacterial origin.

The authors suggest that the selective transport of materials against high concentration gradients is a result of the circulation of fluid through differentially permeable membranes. They believe that there is a continuous flow of fluid into and out of the gut during absorption. D.L.E.

313. The Blood Volume of Normal Dogs. JOHN H. GIBSON, 2ND, JOHN L. KEELEY AND MICHEL PIJOAN, Lab. of Surgical Research and Dept. of Medicine, Harvard Medical School. Amer. J. Physiol. *121,* 3, p. 800, March, 1938.

The merits of the various techniques used in determining blood volume are discussed. Original data on plasma, cell and total blood volume, hematocrit and hemoglobin value of venous blood, and blood velocity rate of 50 dogs are presented. In terms of cubic centimeters per kilogram in dogs of from 5 to 30 kgm. in weight, plasma volume ranged from 41.2 cc. to 51.7 cc.; cell volume, from 36.4 cc. to 54.6 cc.; and total blood volume, from 84.0 cc. to 97.3 cc. No distinct difference in plasma, cell or total blood volume in relation to weight exists between male and female dogs. With increase in body

weight, and the accompanying increase in total blood volume, there is an increase in hematocrit and hemoglobin values, and a slowing of blood velocity rate. This indicates that total blood volume bears a direct relationship chiefly to the amount of muscular tissue in the animal. D.L.E.

314. Further Evidence for a Mammogenic Hormone in the Anterior Pituitary. E. T. GOMEZ AND C. W. TURNER, Dept. of Dairy Husbandry, Missouri Agr. Exp. Sta. Proc. Soc. Exp. Biol. Med. *37,* 4, p. 607, Jan., 1938.

Further evidence is presented indicating that the pituitary gland is the seat of production of a factor or factors which stimulate the growth of the duct and lobule-alveolar systems of the mammary gland. This principle, called the "mammogenic hormone," is present in the pituitaries of cattle when pregnant. The growth of the mammary glands of castrated female rabbits and rats was stimulated by the daily injection of such pituitaries. That this principle is not identical with the lactogenic hormone is indicated by the lack of response with non-pregnant cattle pituitaries containing considerable amounts of the lactogenic hormone. S.W.M.

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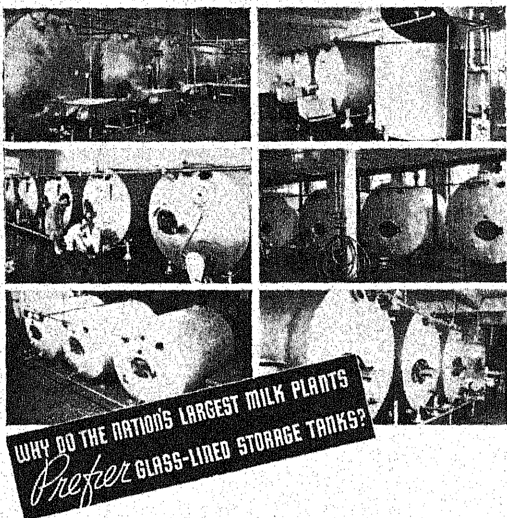

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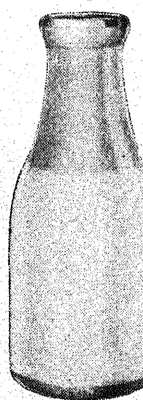

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// JOURNAL OF DAIRY SCIENCE

VOLUME XXI AUGUST, 1938 NUMBER 8

PEDIGREE PROMISE AND PROGENY TEST AMONG SIRES PROVED IN IOWA COW TESTING ASSOCIATIONS[1]

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Bulls which were proved in Iowa Cow Testing Associations, according to the rules of the Dairy Bureau in effect before 1936, were studied to see (1) how many of their parents and grandparents had been tested for production and (2) how closely the production testing in the bull's pedigree indicated either the average production of his daughters or the average increase of his daughters over their dams. This study was confined to the 303 Holstein-Friesian sires (which constituted about half of all sires proved) so that differences in breed averages would not obscure the intra-breed situation, which alone is of practical interest to the breeder who follows a policy of pure breeding or of consistently grading toward one pure breed. We see no *a priori* reason to suppose that the relation between pedigree promise and progeny performance would be different in other breeds.

Each bull had at least five tested daughters out of cows also tested in C.T.A. herds. About half of the bulls had *only* five such daughter-dam pairs. Less than one-fifth of them had more than eight pairs. For the present study the average fat production of the daughters (or of the mates[2]) of each bull was treated as a single item, regardless of the number of daughters (or mates) in that average. About half of the bulls were proved by association-year records; that is, by using as the measure of the cow's production her total production during the twelve months of the association year, regardless of her stage of lactation or lactations. The others were proved by lactation records; that is, by using for the cow's production her production during her whole lactation, or during the first 365 days if her lactation was longer than that. The association-year records were corrected to maturity by considering the two-year-old record as 70 per cent, the three-year-old record as 80 per cent, and the four-year-old record as 90 per cent of the mature record. The lactation records were corrected to maturity by the Bureau of Dairy Industry

Received for publication December 13, 1937.

[1] Journal paper No. J-510 from the Iowa Agricultural Experiment Station.

[2] The dams of the bull's daughters are hereafter called the bull's mates, to distinguish them from the bull's own dam.

factors now in general use. When a cow had more than one record the highest was used. No case was included where the daughters or mates were known to have been milked more than twice a day but, as the number of times milked was not noted on the earlier reports used in proving sires, a few such cases may be included.[3]

As production records for the bulls' parents and grandparents we used only Advanced Registry records more than 305 days in length.[4] All such records completed before the end of 1936 were included. These records were corrected to the "mature B" basis (mature cows milked three times a day) by the factors used by the Holstein-Friesian association. Most of the tested dams and grandams of course had only one A.R. record. Where a cow had more than one A.R. record the average of those was used. For each sire and grandsire the average of the A.R. records of all his daughters was used as his A.R. test.

When the daughter average, the mate average and the average increase of each sire's daughters over his mates were each treated as single items, the means and standard deviations[5] of those items for these 303 sires were as follows:

	Pounds of butterfat	
	Mean	Standard deviation
Mates	416	78
Daughters	430	82
Increase	14	68

[3] Correlations between individual daughters and dams within the group used to prove each sire indicate that individual differences in the fat records were about one-fourth caused by hereditary differences between the cows. Differences in test (percentage of fat in the milk) were about one-half caused by hereditary differences between the cows. The lactation records and the association-year records seemed about equal in their accuracy as indicators of the cow's heredity (JOURNAL OF DAIRY SCIENCE 19: 429–430). A later study of 305-day lactation records used since 1935 in proving bulls in Iowa indicated that intra-herd differences in unselected single records of fat production were about 43 per cent permanent throughout the cow's lifetime and about 28 per cent hereditary (JOURNAL OF DAIRY SCIENCE 20: 440–441). We hope that these studies of heritability can be extended soon.

[4] Many of the dams and some of the grandams of these bulls had C.T.A. records, but those were not at that time systematically recorded in any one place where we could inquire what records existed concerning each cow or bull. We can only guess at the amount of C.T.A. testing in the pedigrees of these bulls. Among 1,055 bulls in use in Iowa C.T.A. herds in 1937, 45 per cent were out of C.T.A. tested dams and another 39 per cent were out of A.R. tested dams with 4 per cent being out of H.I.R. tested dams and only 12 per cent being from dams not tested at all. Since the 303 bulls studied here were from an earlier time (already proved before the end of 1935), it seems certain that the proportion of C.T.A. testing in their pedigrees was less than this, but we do not know how much less.

[5] These standard deviations and the correlations were corrected for what little heterogeneity there was between lactation and association-year records.

The correlations between these three items were as follows:

Mates and daughters	+.64
Mates and increase	−.38
Daughters and increase	+.47

The rather high correlation between the average of the bull's mates and the average of his daughters comes from two biologically diverse sources. The first is the genetic fact that daughters get half of their inheritance from their dams and hence tend to resemble those dams somewhat—a correlation which the process of averaging makes fairly high between *averages* of a bull's mates and *averages* of his daughters, even when it is low between *individual dam* and *individual daughter*. The second is the heterogeneity of management and feeding practices from one herd to another, whereby dam and daughter (which are nearly always tested in the same herd) would in many cases have had their records both raised or both lowered by the environmental circumstances characteristic of that herd but not of all herds. The negative correlation between mates and increase is only another way of expressing the well-known general tendency for offspring to regress from a parent toward the mean of the race, this regression itself resulting from two quite distinct causes. The first of these is that the size of a cow's record is affected by other things besides her breeding value and therefore the cows with the highest records generally do not have as good heredity as their records (if taken at face value) would indicate, while the cows with the lowest records generally are not quite as poor as their records. The other fact causing this regression is that the best cows are not always mated to the best bulls and the poorest cows are not always mated to the poorest bulls. The daughters, getting half of their inheritance from each parent, therefore generally tend to be poorer than their dams in the case of those with the very best dams and better than their dams in the case of those with the poorest dams. The positive correlation between the daughters and the increase is another way of expressing that same regression.

That the 14 pound average increase in one generation measures the true rate of genetic improvement in this population can hardly be maintained with confidence. Too many other possibilities may have affected this figure. For proving the sire only the best record was used when a cow had more than one, and many of the daughters had only made one record when their sire was "proved." Hence the records of the dams in general probably were a bit more highly selected than the records of the daughters. There seems to be a general tendency for herds to improve their management with increasing experience in C.T.A. testing. In many cases the daughters made their records at a later date than their dams and would have been under better management. It is possible that greater effort was made to gather the "proof" on sires which were thought to be doing well than on those which were believed

to have been poor sires, even though the testers were urged to prove all bulls without regard to the level of that proof. These considerations lead us to think that this 14 pounds average increase is of little use as a guide to the rate of genetic change in this population.

The averages of the lactation-year records and of the association-year records, in pounds of butterfat, were as follows:

	C.T.A. year	Lactation year
Number of bulls	149	154
Mates' production	403	429 –
Daughters' production	431	429 +
Increase	28	1 –

There was very little difference in the production of the daughters. The C.T.A. year records mostly come from a slightly earlier period than the lactation records, although there was some overlapping in those dates.

DESCRIPTION OF PEDIGREES

Table 1 shows, as a composite pedigree, the averages and variabilities of the A.R. tests of parents and grandparents. About half of the sires, nearly

TABLE 1

Composite pedigree showing the amount of A.R. testing

303 Sires Proved in Iowa C.T.A.	Sires: 161 had A.R. daughters averaging 631 lbs. $\sigma = 76$ lbs. Quartiles: 580 and 682	Paternal Grandsires: 223 had A.R. daughters averaging 636 lbs. $\sigma = 63$ lbs. Quartiles: 594 and 678 Paternal Grandams: 55 had A.R. records averaging 731 lbs. $\sigma = 109$ lbs. Quartiles: 657 and 805
	Dams: 62 had A.R. records averaging 645 lbs. $\sigma = 105$ lbs. Quartiles: 574 and 716	Maternal Grandsires: 116 had A.R. daughters averaging 619 lbs. $\sigma = 71$ lbs. Quartiles: 571 and 667 Maternal Grandams: 14 had A.R. records averaging 595 lbs.

three-fourths of the paternal grandsires, and more than a third of the maternal grandsires had A.R. daughters.[6] The averages for sires and for the two grandsires were nearly the same and the differences which did appear were statistically insignificant, although in the direction to be expected if such records actually do carry some weight in determining the buyer's choice of bulls.

The standard deviations of these sire tests are about the same for sires and both grandsires. Quartile values (computed from these standard deviations) are shown for convenient use in estimating at a glance whether a particular sire's daughters are extremely high-producing or only moderately so, as compared with daughters of other sires. These quartile values indicate closely enough for practical purposes the boundary between the lowest quarter and the next to the lowest quarter and the boundary between the highest quarter and the next to the highest quarter of the bulls.

The records of the dams and grandams indicate that the most intense selection in dairy cattle breeding is practiced in deciding which dams are good enough to have their sons saved (the high average of the dam) or to have their sons stand at the head of purebred herds (the very high average of the paternal grandams). The general average of all mature A.R. records in Class B in the Blue Book to the end of 1936 is 619 pounds of fat. Differences between this figure and the averages shown in Table 1 may perhaps indicate how slight after all is the selection actually practiced in favor of high production when bulls are chosen to head even such progressive C.T.A. herds as the ones in which these sires were proven.

The records of dams and grandams show larger standard deviations than the records of sires and grandsires. In most cases the sire's and grandsire's records are averages of several daughters, whereas many of the dams and grandams had but one record and few had as many as three. Averages are naturally less variable than single records. The lower variability of the records of male ancestors probably results automatically from the averaging process and does not indicate at all that the male ancestors vary less than the female ancestors in their breeding values. An additional indication of this is the fact that the averages of the bulls' mates in the C.T.A. records are about as variable as the daughter averages for the sires and grandsires.

PEDIGREE AS RELATED TO PROOF

For each ancestor in turn, the 303 bulls were grouped in two groups according to whether that ancestor was or was not A.R. tested. Table 2 shows the average production of mates and of daughters for each of these groupings. The most conspicuous feature of Table 2 is that the bulls with testing in their pedigrees were mated to cows of higher production than were

[6] It should be remembered that some of the others had C.T.A.-tested daughters, but the records of those were not assembled so that we could consult them.

TABLE 2

Differences in the performance of 303 sires according to whether they had or did not have A.R. testing in various parts of their pedigrees

Part of the pedigree concerned:		Averages pertaining to the proof of bulls whose ancestor was: Tested	Not tested	Difference
Sire tested or not tested:	Number of bulls	161	142	
	Mates of these bulls	427	403	+24
	Daughters of these bulls	441	417	+24
	Increase	+14	+14	+trace
Dams tested or not tested:	Number of bulls	62	241	
	Mates of these bulls	444	409	+35
	Daughters of these bulls	444	427	+17
	Increase	−trace	+18	−18
Paternal grandsire tested or not tested:	Number of bulls	223	80	
	Mates of these bulls	421	401	+20
	Daughters of these bulls	435	417	+18
	Increase	+14	+16	− 2
Paternal grandam tested or not tested:	Number of bulls	55	248	
	Mates of these bulls	430	413	+17
	Daughters of these bulls	428	431	− 3
	Increase	− 2	+18	−20
Maternal grandsire tested or not tested:	Number of bulls	116	187	
	Mates of these bulls	431	406	+25
	Daughters of these bulls	435	427	+ 8
	Increase	+ 4	+21	−17
Maternal grandam tested or not tested:	Number of bulls	14	289	
	Mates of these bulls	437	415	+22
	Daughters of these bulls	458	429	+29
	Increase	+21	+14	+ 7

the other bulls. For all six ancestors, except the paternal grandam, those bulls with tested ancestors had daughters averaging higher than the daughters of the bulls from untested ancestors. Because both the mates and the daughters were higher producers where there was testing in the pedigree, the increase of daughters over dams was for four of the six ancestors less for the bulls which had testing in their pedigrees than for bulls without such testing. We interpret Table 2 as indicating that the men who have the higher producing cows pay more attention to selecting their bulls than do the men who have the lower producing cows. By this greater effort they maintain their production at a higher level but they do not make it rise toward still higher levels any faster than it does in the herds where the bulls do not have A.R. testing in their pedigrees. Doubtless there is considerable regression toward

the breed average, both downward from those which have unusually good pedigrees and upwards from those whose pedigrees seem very poor.

Since these sires were proven before the end of 1935, even the youngest of them must have been placed in service before the end of 1931. Many of them were initially selected years earlier than that. On the other hand in some cases the A.R. records in their pedigrees were not made until near 1936. Therefore the comparisons as made here between those with A.R. testing in their pedigrees and those without such testing, include information which the purchaser of the bull in many cases could not have known when he selected that bull.

Considering one ancestor at a time and taking all cases in which that ancestor was A.R. tested, we measured the correlation between the bull's performance and the A.R. test of the ancestor and found the facts shown in Table 3.[7] The question here is how closely the size of the A.R. record indicates a correspondingly good or poor performance of the bull in siring daughters which average high in production or which produce more than their dams. None of the correlations in Table 3 are statistically significant. They are prevailingly positive, but small. The partial correlations between the performance of the bull's ancestor and the performance of the bull's daughters from cows of a given level of production, we think are a bit more dependable than the simple correlation coefficients as indicators of the relation between ancestor's record and bull's performance. The partial correlations are less likely to be distorted by possible relations between the level of testing in the bull's pedigree and the level of production of his mates.

TABLE 3

Correlations between the bull's daughters' production (average as in columns 4 and 5, or increase over dams as in column 6) and the A.R. tests of his ancestors

Ancestor whose test was correlated with the bull's performance	Number of bulls included	Approximate standard error of r	Bull's performance		
			Average of his daughters		Increase of his daughters over their dams
			Regardless of their dams	From cows of a given level of production	
Sire	161	.08	−.02	−.02	−.01
Dam	62	.13	+.24	+.11	−.06
Paternal grandsire	223	.07	+.06	+.10	+.11
Paternal grandam	55	.14	+.10	+.21	+.23
Maternal grandsire	116	.09	+.03	+.01	−.01

[7] Corrected for the slight heterogeneity between lactation and association-year records.

We interpret Table 3 as indicating that the relation between the bull's pedigree and his performance is positive but slight. But in making this interpretation it must be remembered that here the ancestors are considered one at a time, whereas the purchaser of a bull may combine the high records of some ancestors and the low records of others in the same pedigree to arrive at some kind of a weighted estimate of the desirability of the pedigree as a whole. The correlation between such a weighted estimate of the pedigree and the bull's performance would usually be larger, although not vastly so, than the correlations between any one of the ancestors and that performance. We were not able to combine the record of sire and dam and grandparents into a single multiple correlation prediction equation for the bull's own performance, because so few bulls in these data had A.R. tests for all six of those ancestors. A second qualification bearing on this interpretation is that we are here correlating the pedigree record with the *observed* progeny performance. That the progeny test of the bull is not a perfect indication of his breeding value is evident from the fact that the progeny test based on his first five or first ten daughters may be different from a similar test based on his subsequent daughters. That is, in comparing a pedigree with the observed progeny test we are correlating one indication of the bull's breeding value with another indication of the same thing, neither indication being perfectly reliable although one may be more so than the other. Under such circumstances the correlation between either of those indications and the bull's true breeding value, if the latter could be measured accurately, would almost certainly be somewhat higher than the correlation of the one indication with the other. Taking all these things into consideration, we think these correlations give slightly too low an estimate of the real usefulness of the A.R. records in a bull's pedigree as indicating his breeding value.

DISCUSSION

In nearly half of our data the progeny tests of the bulls themselves include only five daughters. Only an eighth of our bulls were proved by as many as ten pairs of daughters and dams. The figures for sires and grandsires in our study included all the tested daughters of each, but in many cases this was as few as three and in but few cases did it go far above ten.

Our correlations are lower than those found by Copeland[8] or by Madsen[9] in the only other reports we have seen of studies closely similar to this one. They found correlations as follows between the average production of a bull's daughters (the production of the bull's mates not being considered) and the production records of the bull's near ancestors:

[8] Copeland, Lynn. 1934. Pedigree Analysis as a Basis of Selecting Bull Calves. JOUR. DAIRY SCIENCE 17: 93–102.

[9] Madsen, Karl. 1932. Inheritance of Milking Capacity. Nature, January 30, 1932.

	Copeland	Madsen	
	Lbs. fat	Lbs. fat	Lbs. milk
Sire's daughters	+.56	+.32	+.25
Dam's own records	+.33	+.18	+.17
Paternal grandsire's daughters	+.25	+.19	+.20
Maternal grandsire's daughters	+.43	+.26	+.19
Paternal grandam's own records	......	+.06	+.03
Maternal grandam's own records	......	+.17	+.11

There are several differences in the data studied. Perhaps the chief one is that Copeland and Madsen included only data on bulls which had at least ten tested daughters. In Madsen's data the average number of daughters per bull was 18 and the average number of records per cow among the dams and grandams was 5.5.

The larger numbers available for the studies of Copeland and Madsen should have tended to give their figures greater dependability and to make them fluctuate less but we cannot see that our figures would have been biased toward lowness by this reason. They might as well have been too large—the scantiness of the material would merely permit them to be more erratic. Our material corresponds closely to the situation which the bull purchaser of today must face. The figures we studied were as much information[10] as the prospective purchaser could get about this bull in early 1937.

It may be worth while to point out that these correlations should be compared not with perfect correlations (which are not to be expected in any case) but with what might be expected in the limiting case in which the differences between cows as revealed by their records or between bulls as revealed by their daughters' records are assumed to be *perfectly* hereditary. This depends in part upon the degree of assortive mating practiced among those animals which do get selected to be parents but, as all dairy breeders are striving for high production, only the fact that some breeders strive harder or more wisely than their fellows toward the common goal can give rise to assortive mating. This surely cannot be intense in the population as a whole. Not enough inbreeding or extreme outbreeding is practiced that this would alter the picture noticeably. Ignoring for the moment the traces of assortive mating and inbreeding which probably exist, the expected correlation between the record of the bull's dam and the average record of his daughters would rise from +.25 toward +.50 as the number of his daughters increased. Similarly the expected correlation between the average record of the bull's sire's daughters and the average record of the bull's own

[10] Except that we did not use 7-day and 30-day records which were more abundant in the older pedigrees, H.I.R. records which are beginning to be available in the pedigrees of young bulls, and C.T.A. records which until recently have not been assembled systematically at any one place and have mostly been left in the barn books of the C.T.A. member in whose herd they were made.

daughters would range from +.125 when each had but a single daughter toward +.50 if each had very many daughters. The correlations between the bull's daughters and his grandparents' records would be just half as large. If all of the bull's ancestors were thoroughly tested and if their records could all be considered at once, the expected correlation between the promise of the pedigree as a whole and the bull's actual performance would range up toward +.71, being restrained by the sampling nature of Mendelian inheritance from going higher than that.[11] The existence of some assortive mating causes the correlation expected when one ancestor is considered at a time to be somewhat higher but has little effect on the dependability of the whole pedigree. The assortive mating merely results in each ancestor indicating to some extent what the other ancestors will be. Therefore the assortive mating causes one ancestor by itself to be a more useful indicator than it would be under random mating but not so much additional information is gained by actually learning the facts about those other ancestors. Perhaps little is to be gained by discussing these abstract conditions further, since in actual practice we face the overwhelmingly important fact that the size of a cow's record or of a bull's daughter average, even under A. R. conditions, is much influenced by many things other than the cow's or bull's heredity and that many of these things are dependent on the herd management or environment in such a way that no amount of increase in the number of records or number of daughters tested will tend to equalize those environmental differences as between animals which are tested in different herds.

That a few of Copeland's and Madsen's correlations are higher than expected, even on the assumption of perfect heritability, might result from undiscounted time trends or from stratification of management practices whereby there may be a noticeable tendency for a buyer to get his bull from a breeder who manages and tests his herd according to somewhat the same standards as the buyer does. Or if the divergence of ideals between those who put type first and those who put production first is distinct (as differences in emphasis could make it, even when all breeders are paying some attention to both type and production) and if there are many holding each ideal, then the assortive mating thus introduced could raise the correlations with individual ancestors above the limits expected under the abstract conditions. It seems profitless to speculate farther in this direction now, but we do think it worth while to mention that some of Copeland's and Madsen's correlations are rather higher than the general evidence about heritability

[11] This is the multiple correlation to be expected between the genotype of an individual offspring and the genotypes of its two parents in a population mating at random. No amount of knowledge about the ancestors can lead farther than toward a perfect knowledge of the genotypes of the two parents. See Genetics 6: 111–161 for more details concerning these biometrical relations.

of differences in milk and fat production leads us to anticipate, whereas our own coefficients are somewhat lower than we had anticipated.

The practical implications of these studies are that pedigree promise is worth something in selecting a bull but as a cold-blooded business proposition it should not be valued too highly. As a usual thing the prospective purchaser can reasonably expect to get in the daughters of his bull only a small part of that superiority over the rest of the breed which his bull's parents and grandparents showed. Often the pedigree is almost the only guide which the purchaser has, besides seeing that the bull meets his minimum standards of type and health. Like the weather forecasts, pedigree promise has some value, even if it isn't infallible! But, just as the traveler on a day when fair weather is predicted may take along an umbrella or raincoat if it doesn't cause too much expense or trouble, so the purchaser of a bull with even an extraordinarily good pedigree may find it best to sample the bull fairly and wait to learn the results before be builds his breeding plan too extensively around that bull, if the cost of sampling and waiting isn't too large. The more one knows about the conditions under which the records in the pedigree were made and allows for the differences which those conditions made in the records, the more accurate the pedigree becomes as an indicator of the bull's breeding value, but this is sharply limited both by the fact that one cannot make absolutely perfect allowances for those conditions, no matter how well he knows them, and also by the biological limits which the sampling nature of inheritance places on the accuracy of pedigree estimates. The existence of these distinct limits makes the law of diminishing returns apply to the effort spent in detailed study or standardizing of pedigrees. It is often worth while to find out the main features about the conditions under which the bull's ancestors were tested—*e.g.,* whether their records are selected ones or life-time averages, what the average production of the other cows in the herd was in the same years, whether they were milked oftener than twice a day, and roughly how well they were fed—but one quickly comes near the point where further study of these details will improve the accuracy of the pedigree estimate so little that such further study is scarcely worth the trouble.

SUMMARY

A study of the pedigrees of 303 Holstein-Friesian bulls proved in Iowa Cow Testing Associations before 1936 showed:

1. That the bulls with A.R. testing in their pedigrees were used in higher producing herds and had higher producing daughters than the bulls without such testing but, because of the higher production of their mates, the bulls with testing in their pedigrees did not increase the production of their daughters any more than the others did.

2. The correlations between ancestor's A.R. records and the bull's progeny performance were prevailingly positive but were so small as to be statistically insignificant on the amount of data available.

Although so limited in amount as to make them subject to large sampling errors, the data are compatible with the general conclusion that it is desirable to select bulls which have tested ancestors and whose tested ancestors have high records but that one can expect to gain in the daughters of such bulls only a small fraction of that superiority which their tested ancestors showed, as compared with the breed average.

OBSERVATIONS ON THE SPLITTING OF BRICK CHEESE

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At certain seasons of the year, a very characteristic defect may appear in Brick cheese when it is seven to fourteen days old. Excessive development of gas in the cheese causes holes which commonly become large enough to split the cheese. This defect is sometimes called "late-gas" in order to distinguish it from the gas which occasionally forms during the making or draining processes. The defect may appear in one part of a cheese as shown in figure 1, or it may extend throughout the length of the cheese, as

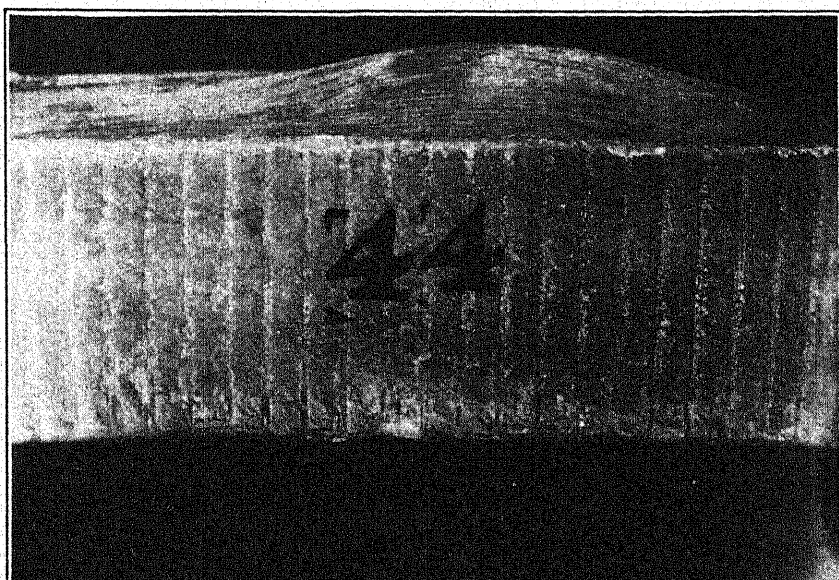

FIG. 1. Swelling of the cheese in a small area may occur when the gas development is localized. (The cheese is about 3 in. high at the edge. The whole cheese is not shown in this picture.)

illustrated in figure 2. A typical cross section of a defective cheese is shown in figure 3. This figure illustrates not only the splitting but also the "sweet" holes, which are sometimes associated with the splitting. Frequently a flat, metallic flavor appears in the cheese, even before the swelling occurs; at other times the cheese has a rather pleasing, sweet flavor. The defect has been observed most frequently in Winter and early Spring.

Received for publication February 26, 1938.

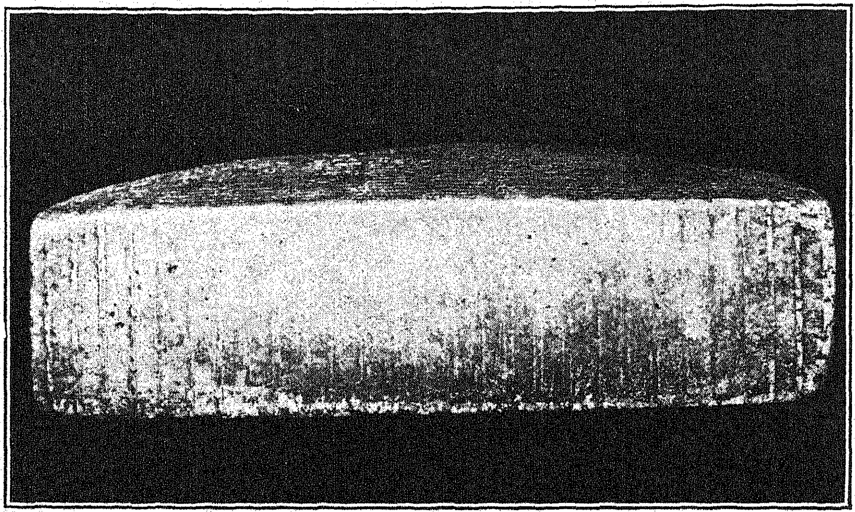

FIG. 2. Swelling of the cheese may take place throughout the entire length of the cheese when gas development is general. (The length of the cheese is 10 in.)

It occurs in some factories year after year, sometimes affecting all and sometimes only a portion of each day's make. Such cheese cannot be readily sold on the retail market.

It has been possible to observe the defect in this laboratory and in com-

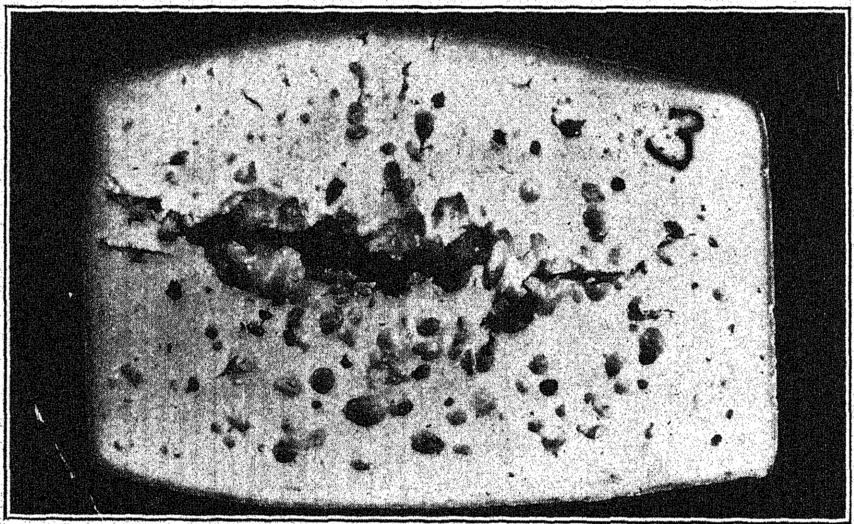

FIG. 3. A cross section of a cheese showing the splitting defect and numerous gas holes. (The size of the cheese section is approximately 3 × 5 in.)

mercial plants from time to time during the past six years. It is the purpose of this discussion to point out some of the conditions which seem to be associated with its occurrence in the cheese.

When the defect was first observed in our manufacturing laboratory, special precautions were taken to sterilize all cheese equipment and to change the starters used in the manufacture of the cheese. Milk for cheese making was pasteurized and every precaution was taken to avoid subsequent contamination. Despite these precautions, the cheese continued to develop the characteristic splitting. Process cheese made from this defective cheese also developed a similar type of fermentation. Undoubtedly the milk from which the cheese was made contained the responsible organisms when it was delivered by the farmers, and ordinary pasteurizing temperatures failed to destroy them.

EXPERIMENTS FROM 1933 TO 1935

It seemed probable that the gas-producing organisms were spore-forming anaerobes. Samples of the gassy cheese were, therefore, ground and placed in flasks containing sterile milk, to which a small amount of reduced iron had been added. These flasks were incubated at 37° C. for 15 hours. Such violent fermentations occurred in several of the flasks that the cotton plugs were dislodged. A number of pure cultures of spore-forming anaerobes were eventually obtained from these sources. Mixtures of several of the more active of these cultures were used to inoculate milk for cheese when it was considered necessary to obtain the defect. The futility of such inoculations was discovered eventually when controls as well as inoculated lots developed the defect.

From 1933 to 1935 several conditions of manufacture were studied, including: variations in the ripening of milk for cheese making; the type of starter; temperature of heating; time of dipping; moisture content of the cheese; methods of salting; the amount of salt in the cheese and the effects of pasteurization. These experiments will not be discussed in detail, but some of the more interesting relationships will be indicated.

Varying the time of ripening the milk before setting was carried to an extreme by holding the milk, to which normal amounts of *S. lactis* starter had been added, for two hours at the setting temperature before adding the rennet. The unripened milk was mixed with the necessary amount of rennet immediately after the starter was added. The ripened milk usually developed maximum or excessive amounts of acid, but the cheese was closer in texture, as might be expected, than that made from the unripened milk. Several lots of cheese from both ripened and unripened milk, however, were criticized for gas development and splitting.

S. lactis, *L. bulgaricus*, and *S. thermophilus* cultures were used in paired experiments in 1933. Each starter culture was used alone in pasteurized

milk, and utmost care was taken in the manufacturing process to prevent transfer of organisms from one vat to another.

The results indicated that the formation of excessive gas in the cheese after a week or more of curing might result in two distinct types of open-texture defect, depending upon the acidity of the cheese itself rather than upon the acid-producing organism used as starter. Cheese made with *L. bulgaricus* had the greatest and that made with *S. thermophilus* the least acid development. Cheese containing *L. bulgaricus* showed the splitting defect; that made with *S. lactis* showed both splitting and excessive gas formation; while the use of *S. thermophilus* culture tended to develop cheese with many very large holes but with practically no splits. High acid development had a slight suppressing effect upon the formation of gas. Apparently the short-bodied, acid-type cheese tended to split easily following an excessive gas formation which, in sweet cheese with more elastic body, only produced large gas holes. When splitting occurred in sweet cheese, it was preceded by the formation of large holes which finally broke into the characteristic splits when the elastic limit of the cheese was exceeded.

It is usually supposed that high moisture in cheese tends to exaggerate fermentation defects. This does not seem to apply, however, to the splitting defect. Moisture was regulated by changing the time of dipping and by using different temperatures of heating. The results indicated that the differences could be attributed more to the extent of acid developed than to the amount of moisture remaining in the cheese. For example, when the time of dipping was varied, the moisture content of the cheese ranged between 37.7 and 42 per cent. The lowest texture score was given cheese with a moisture content of 38.7, and the best score to cheese with 42 per cent moisture. In general, whenever the conditions of manufacture in these experiments induced the production of a sweeter type of cheese, the judges found more of the characteristic openness than in lots made from identical milk in which more acid was developed during the manufacturing process.

The effects of salt were studied on three different days by dividing the cheese from one vat into four groups. Each group was given a different salting treatment so that the average salt content of the lots of cheese in these four groups averaged 2.0, 2.4, 2.5 and 2.9 per cent. These differences were obtained by exposing the cheese for different periods of time to the brine and by varying the washing treatments by using brine for one group and fresh water for another. All four groups showed some gas defects because the pasteurized milk from which the cheese was made had been inoculated with cultures of anaerobic gas-forming types of organisms. The groups which averaged 2.0 and 2.4 per cent salt were regarded as less desirable in texture by the judges because of the presence of the late-gas and splitting defect in some of the cheese in these groups.

The association in this experiment of the defective texture with the

lower salt groups suggested that the size of the cheese loaves, one of the commonest causes of variations in salt in Brick cheese, might be a significant factor in relation to the defect. Measurements in 1934 and 1935 of texture, salt and thickness of loaves before salting were available on fifty-five lots of cheese made, not only during studies of the gas-defect, but during other experiments as well. Averages of these values are summarized in Table 1. The trends of the average values shown in this table indicate that

TABLE 1

Relation between texture score and the average thickness of loaves and salt content of Brick cheese

Texture score*	No. of lots	Thickness	Salt content
		inches	%
Below 2.0	1	1.38	3.93
2.0–2.9	17	2.60	3.16
3.0–3.9	25	2.64	3.29
4.0–4.9	10	2.80	2.96
Above 5.0	2	2.63	3.05

* 1=excellent; 2=desirable; 3=satisfactory; 4=objectionable; 5=very objectionable.

when the thickness of the cheese increases, there is a loss in texture score. This loss can be attributed to all defects, including "splitting." It is interesting that the lowest average salt contents in this table tend to be associated with the cheese of inferior texture. The thickness of the cheese, however, is apparently more closely related to the texture score than is the salt content. This may be explained by the relation between thickness of cheese and the formation of mechanical and gas holes.

Mechanical holes in Brick cheese are probably first formed by the trapping of free whey between curd particles. Gradually the whey escapes between the curd particles or is absorbed by the curd as it cools. If the whey is released before the curd cools too much, the curd flows into and closes, or partially closes the cavities left by the whey. Since whey escapes more rapidly from small loaves of cheese, such loaves would be expected to have fewer mechanical openings than large loaves.

In a similar manner, it is to be expected that more of the gas formed in small cheese would diffuse through it and escape without forming holes. These combined facts partially explain the relative freedom from either mechanical or gas holes of the layer of curd immediately beneath the rind of the cheese pictured in Figures 1, 2 and 3.

The use of salt to control fermentations is generally known in the food industry and is appreciated in the manufacture of some varieties of cheese. Swiss cheese makers, for example, practice salting heavily those spots on a cheese which show excessive swelling in order to check the formation of gas under that area. Since large loaves of Brick cheese become permeated

with salt more slowly than small loaves, it is logical to assume that salt might have a greater inhibiting effect on gas development in the small loaves of Brick cheese.

Regulation of the size of loaves of Brick cheese is not always easy. Mechanically it is difficult to estimate the amount of free whey in the curd at dipping, and it is practically impossible to measure exactly the amount of curd placed in each mold. Sudden changes in weather cause differences in milk composition and acid development, which in turn influence the yield of cheese per hundred pounds of milk. Effects of such changes are difficult to predict so that it is not surprising to encounter variations in size of loaves. Actually trade demands may require loaves of a certain thickness or weight which might actually favor the occurrence of the splitting defect.

Slight differences in late-gas development were observed in raw- and pasteurized-milk cheese when both lots were made from identical milk. Raw-milk cheese tended to develop somewhat more acid during the manufacturing process than did the pasteurized-milk cheese. When the raw-milk cheese developed the typical splitting defect, the pasteurized-milk cheese showed the same defect very slightly exaggerated by the presence of more of the large sweet holes. Actually, texture grades for these two types of cheese were practically identical.

The results of these early experiments indicated that, although no single factor was wholly effective, it might be possible, by regulating acidity, salt content, and size of the cheese to exercise some measure of control over the defect.

DEFECTIVE CHEESE FROM FACTORIES

During the winter of 1936–37, visits were made to a Brick cheese factory which was experiencing considerable trouble with late-gas formation. From 15,000 to 25,000 pounds of milk were being made into cheese each day. Only a portion of the cheese developed the splitting defect; the rest of it was entirely satisfactory and of high quality. The defect was not accompanied by undesirable off-flavor. The factory was visited at weekly intervals for

TABLE 2

Relation of average acidity and composition of Brick cheese at two weeks of age to late-gas formation

Degrees of defect*	No. of lots	Acidity	Moisture	Salt	$\frac{\text{Per cent salt} \times 100}{\text{Per cent } H_2O}$
		pH	%	%	
0	9	5.08	38.5	1.26	3.27
1	6	5.14	38.7	1.27	3.28
2	3	5.16	40.2	1.44	3.60
3	5	5.08	39.7	1.34	3.37
4	9	5.12	39.1	1.27	3.24

* 0 = none; 1 = slight; 2 = definite; 3 = pronounced; 4 = extreme.

several weeks, and samples of cheese, some of which were split, and some of which were satisfactory, were taken from the curing room at approximately ten days of age. These lots of cheese were scored and analyzed for acidity, moisture and salt. The results of these analyses are shown in Table 2. Of the 32 different lots of cheese examined, nine of them showed no splitting defect; six showed it slightly; nine lots were extremely bad. The analyses in Table 2 were made upon half-inch cross-section slices of each cheese and represent the composition of the cheese as a whole. In general, the average values for acidity, moisture and salt contents were practically the same for satisfactory and defective cheese. Since some of the satisfactory lots were taken from the same vats which produced defective cheese, it seemed possible that the defect might be caused by a treatment following the curd-making process itself.

In nine of the lots of cheese taken from the factory, analyses were made for acidity, moisture and salt on portions of the cheese removed from the center of the loaves. The results of these analyses are presented in Tables 3 and 4. The averages in Table 3 indicate slight differences in composition between the center portions and the cheese as a whole, both in acidity and

TABLE 3

Relation between late-gas formation and the average acidity and moisture in the whole cheese and in the center portion

Degree of defect*	No. of lots	Acidity		Moisture	
		Whole cheese	Center	Whole cheese	Center
		pH	*pH*	%	%
0	3	5.12	5.09	37.9	37.4
1	2	5.12	5.08	39.1	38.4
2	1	5.11	5.11	41.9	39.3
3	1	5.03	4.98	38.3	37.6
4	2	5.08	5.04	38.7	38.2

* 0 = none; 1 = slight; 2 = definite; 3 = pronounced; 4 = extreme.

TABLE 4

Relation between late-gas formation and the average salt content of the whole cheese and the center portion

Degree of defect*	No. of lots	Salt		$\frac{\text{Per cent salt} \times 100}{\text{Per cent moisture}}$	
		Whole cheese	Center	Whole cheese	Center
		%	%		
0	3	1.48	1.10	3.92	2.95
1	2	1.39	1.11	3.57	2.90
2	1	1.35	0.97	3.22	2.47
3	1	1.26	1.07	3.28	2.84
4	2	1.18	0.72	3.05	1.86

* 0 = none; 1 = slight; 2 = definite; 3 = pronounced; 4 = extreme.

moisture. Practically no differences exist between the acidities and moisture contents of the defective and satisfactory cheese. Table 4, however, indicates a generally lower salt content in the most defective cheese and distinct differences between the center portion and the whole cheese. This is even more noticeable when the salt content is stated as per cent of salt in the moisture of the cheese.

The factory operator was advised to increase the salt content of the cheese. Some practical difficulties arose in this connection. The length of time of holding the cheese in the brine could not be increased because the brine tank capacity was already being used to its utmost. The salt concentration of the brine was increased from 75 to 90 per cent saturation as measured by a salt hydrometer. Some of the lots of cheese still showed the splitting defect. This was attributed to the fact that double layers of cheese were floated in the brine tank, and the top layers, naturally, were less exposed to the brine than those beneath. A wooden lattice was made and placed over each layer of cheese as it was put in the brine. The layers were then submerged by weighting down the wooden lattice work. This exposed more cheese to the action of the salt. The defect was still not entirely eliminated, however. Observations of the handling of the cheese in the curing room disclosed the fact that occasionally fresh water from a hose was turned on the cheese after they were taken from the brine tank and while they were on the shelves in the curing room. This rinsing process removed the brine on the exterior of the cheese, reduced the salt content of the cheese and may explain why the defect still appeared from time to time.

These results tended to confirm some of the observations on the influence of salt that were made in 1934–35 and suggested that the typical splitting defect might be developed by special treatments of cheese which would normally be entirely satisfactory.

PRODUCING DEFECTIVE CHEESE FROM NORMAL LOTS

In the routine work of the laboratory, a considerable amount of experimental Brick cheese was being produced during the year 1936–37. All lots of cheese were normal and without late-gas defects. In order to verify the earlier observations and the results which seemed to be significant in factory practice, certain loaves of cheese were subjected to some treatment intended to influence the amount of salt in the cheese.

The first experiment consisted of placing a larger portion of curd than usual in the hoops at dipping on three different days in order to make excessively large cheese. Loaves weighing between six and seven pounds were produced in this manner as compared to the normal, which approximated five pounds in weight. Both large and normal cheese were treated in the usual manner accorded the normal cheese. Table 5 shows the results which were obtained when the cheeses were finally analyzed for salt and scored.

TABLE 5

Comparison of normal and large-sized cheese

Lot	Size of cheese	Per cent of salt	Late-gas
1	Normal	2.02	None
	Large	1.10	Definite
2	Normal	1.79	None
	Large	1.02	Many, large, sweet holes
3	Normal	1.91	None
	Large	0.99	Definite

The normal cheese contained more salt than the large cheese. In every instance the normal lots were satisfactory in texture while the large cheese either developed the splitting defect or developed so many large sweet holes that the loaves swelled almost to the splitting point.

In another experiment the amount of salt incorporated in the cheese was reduced by holding the cheese in the brine bath for 24 instead of the usual 48 hours. Typical results from three different days are shown in Table 6.

TABLE 6

Comparison of cheese salted 24 to 48 hours

Lot number	Hours of salting	Per cent of salt	Late-gas
1	48	1.70	None
	24	1.06	Definite
2	48	1.97	None
	24	1.30	Definite
3	48	1.57	None
	24	1.01	Definite

Here again the salt content of the normal cheese is higher than that of the abnormal cheese. In the cheese which was salted for 48 hours, the splitting defect did not occur. In the cheese salted for the shorter period of time, the splitting defect was noted in every instance. In those lots salted for 24 hours, the defect appeared even when the acidity of the cheese was in the range where cheese is criticized for excessive acid development. In those lots where the pH values were well above the acid limits, the splitting defect occurred to a greater degree. One lot of cheese weighing only 3 pounds 7 ounces and containing a relatively small amount of salt developed the splitting defect. The size of the cheese in this instance did not prevent the splitting defect when other conditions favored its occurrence.

DISCUSSION

The significance of the results of the experiments with late-gas formation from 1933 to 1935 was so doubtful at that time that they were not published.

Even now the chief reason for summarizing them is to show the reason for later observations and experiments and to emphasize the fact that more than one factor must be involved. Additional evidence of the importance of these other unknown factors is shown, for example, in Table 4 in which are presented much lower percentages of salt in satisfactory cheese than those associated with the splitting defect in the 1933 to 1935 experiments. More evidence of this same type was accumulated in 1936, when about forty factories in all Brick cheese producing areas of Wisconsin were visited at approximately monthly intervals from January until August, and loaves of cheese were brought to the laboratory for scoring and analysis. The frequency distribution of the salt analyses of the cheese is presented in Table 7. The

TABLE 7

Salt content of commercial Brick cheese collected between January and August, 1936, from 40 Wisconsin factories

Per cent salt in cheese	No. of samples
1.10–1.29	16
1.30–1.49	27
1.50–1.69	15
1.70–1.89	23
1.90–2.09	18
2.10–2.29	14
2.30–2.49	7
2.50–2.69	4
2.70–2.89	7
2.90–3.00	1

salt content ranges between 1.1 and 3.0 per cent. Observations in this laboratory would indicate that at least one-third of these lots of cheese contained so little salt that they should have been susceptible to the late-gas defect. Obviously, low salt content alone, however, cannot induce the defect if other conditions do not favor excessive gas formation. The reasons why some lots of cheese, despite the relatively low salt contents shown in tables 4 and 7, failed to show the late-gas fermentation are undoubtedly similar to those which determine the appearance of any gas defect in cheese. Small numbers, at least, of the causal organisms can usually be found in milk used for cheesemaking, but there are thresholds of acidity, temperature treatments and moisture contents which definitely limit their development. Such thresholds vary, however, depending upon the number, vitality and activity of the causal organisms. Low salt content, therefore, is regarded as only one, perhaps of several factors, which seem to make cheese more susceptible to the action of the organisms responsible for late-gas formation and splitting of Brick cheese. Certain conditions might be pointed out which seem to induce or to be associated with the development of late-gas, but for which no experimental evidence has been accumulated.

Organisms of the late-gas-forming type are undoubtedly essential for the

production of the defect. These gas producing organisms probably contaminate the milk on the farm, since even the most unusual precautions in the factory failed entirely to check this defect. It is probably true, also, that these undesirable types constitute a greater proportion of the milk flora during the periods when the herds are kept in the barns. When these organisms are present in sufficient numbers there is some reason to believe that the preventive measures mentioned in this discussion might be entirely ineffective. This is illustrated by the data in Table 1. Despite abnormally high salt content in that cheese the defect still persisted.

The general occurrence of the defect during the colder months of the year indicates that possibly the chilling of the curd during the dipping process may be partly responsible for the trouble. When the curd is dipped into the molds, it is customary to fill all the molds at first, then after the curd has settled slightly, the worker returns and adds to the molds sufficient curd to give the cheese its proper size. During this interval, cooling of the curd surface weakens its ability to knit together. Such a condition may even occur in the cooler days of Spring and Summer if the dipping is unnecessarily slow. The fact that the splitting of the cheese always occurs in the horizontal direction might be attributed to this manner of pouring the curd into the molds. It is a fact, of course, that the resistance to swelling is less along the horizontal plane of the cheese.

The common occurrence of the defect in Winter and Spring might be traced to the generally lower temperatures in the draining and salting rooms. Winter milk contains fewer lactic-acid-producing organisms. Factory starters frequently do not supply this need. As a result the cheese curd drains slowly and is frequently too sweet. Low temperatures in the draining room tend to delay necessary acid production. Low temperatures in the salt tank or salting room also tend to decrease salt absorption. It seems possible that such a combination of factors, at a time when contamination is naturally high, might be disastrous. The appearance of the defect in only a portion of the cheese made from the same vat of curd may be explained by variations in:—size of cheese, washing treatments, exposure to salt brine or temperature of cheese during the draining process.

Sometimes during the study of factory-made cheese, excessively large amounts of extraneous material were found. Frequently cow hair, bits of straw, or chaff from grain were found in the split portion of the cheese. The presence of such materials naturally weakened the curd structure and encouraged the splitting of the cheese at those points. It is probably true, also, that these bits of foreign material carried into the cheese excessively large amounts of those organisms responsible for the formation of the gas itself. Obviously, the presence of such foreign material is not to be condoned. A careful maker will not be guilty of permitting such substances

to get into the cheese vat, either through the milk itself or by exposure of the curd in the factory during the dipping operation.

SUMMARY

This report indicates that lack of acid development, low salt content and large loaves of cheese tend to encourage the development of late gas in Brick cheese. Although these factors are important they are not necessarily the only ones involved in the production of this defect.

SEEDING TEST FOR CRYSTALLINE BETA LACTOSE

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INTRODUCTION

Many times it is of great importance to know whether the lactose in a dried milk product is present as a glass or is in the crystalline state, and if in the crystalline state whether the crystals are alpha hydrate, beta anhydride, or both. This information can be obtained rather easily by taking advantage of the property of lactose to form fairly stable supersaturated solutions. Below 93° C., supersaturation with respect to alpha lactose hydrate predominates, and above this temperature, supersaturation with respect to beta lactose anhydride. If the concentration is so controlled that the solution is supersaturated with respect to one form and is undersaturated with respect to the other forms of lactose, advantage can be taken of the supersaturated state of the solution to test, by seeding, for the presence in the crystalline state of the form of lactose with respect to which the solution is supersaturated.

SEEDING TEST FOR CRYSTALLINE ALPHA LACTOSE HYDRATE

Hudson and Brown (1) described a test for crystalline alpha lactose hydrate based on this principle. They cooled from 20° C. to 0° C. a solution saturated with lactose, with the forms in equilibrium at 20° C., and used the solution for testing beta lactose preparations which were suspected of containing crystalline alpha lactose hydrate. Since crystallization proceeds slowly at 0° C., and such a temperature is not conveniently obtained in the laboratory, Troy and Sharp (2) used a modification of the test which is much more sensitive and convenient. A solution of lactose saturated at 50° C. with the forms in equilibrium was filtered, and cooled to 20° C. To each of several 10 ml. portions of this solution, in test tubes, was added about 25 mg. of test sample, and the tubes were stoppered and shaken. If alpha lactose hydrate crystals are present, the solution becomes turbid in about 15 minutes. If the solution remains clear for about one hour, the absence of alpha lactose hydrate crystals is indicated. Some idea of the amount of alpha lactose hydrate crystals or nuclei can be obtained by the time required to induce crystallization and by the degree of turbidity of the solution. The test is sensitive, and care in handling the solution is necessary to prevent contamination with crystalline alpha hydrate crystals; on the other hand a few perfect alpha lactose hydrate crystals when present may not induce copious crystallization of the solution. Dehydrated alpha

Received for publication February 17, 1938.

lactose hydrate also induces crystallization, because it hydrates before it dissolves, and the characteristic arrangement of the molecules of the sugar is not altered by simple removal of the molecules of water. Beta crystals and lactose in the glass form do not induce crystallization.

SEEDING TEST FOR BETA LACTOSE CRYSTALS

A seeding test for beta lactose anhydride crystals, based on the same principle, has been used in this laboratory for a number of years, and several hundred samples have been tested. In carrying out the test it is necessary that a solution supersaturated with respect to beta lactose and undersaturated with respect to alpha lactose hydrate be prepared and maintained for a period of time sufficiently long to determine whether crystallization can be induced by adding a small portion of a product suspected of containing beta crystals.

The test is carried out by means of apparatus of the type illustrated in

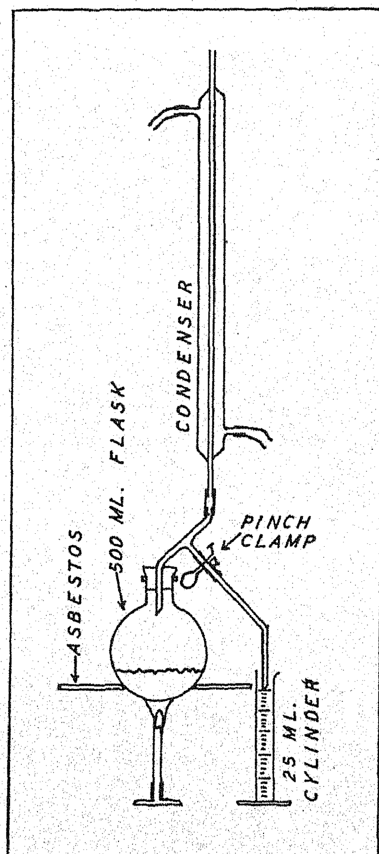

FIG. 1. Apparatus used for detecting beta lactose crystals in a product by its seeding effect on a solution supersaturated with respect to beta lactose.

Figure 1. A 500 ml. short-necked, round-bottom flask is attached to a condenser by means of a bent T tube, the stem of which is connected through rubber tubing and a pinch clamp to a 25 ml. graduated cylinder. It is possible to operate this apparatus either for refluxing or for the removal of solvent by distillation, by closing or opening the by-pass. No spattered solution should be permitted to dry on the inner walls of the flask above the surface of the solution, because this material will contain crystals of both alpha lactose hydrate and beta lactose. These crystals will eventually wash down into the solution and will induce crystallization. The drying is prevented by an asbestos guard $\frac{1}{4}$ inch thick, with a round hole of such a size that no direct heat from the flame is permitted to come near the surface of the boiling syrup.

To prepare the solution for the seeding test 58 ml. of water is added to 100 grams of alpha lactose hydrate in the flask, which is attached to the condenser in the refluxing position. In the early stages of heating the contents of the flask must be agitated by shaking to prevent the burning of th lactose. The solution should be boiled with the condenser in the refl position until all of the crystals have disappeared. The by-pass is opened and 20 ml. of water is removed by distillation; the by-pass is t closed and the condenser is operated in the refluxing position. The port of the T tube above the pinch clamp traps about 1 ml. of water. The solution in the flask is now supersaturated with respect to beta lactose anhydride and is undersaturated with respect to alpha lactose hydrate.

To carry out a test the stopper is removed and about 25 mg. of the material to be tested is knocked from a spatula into the flask. The stopper is then quickly replaced, and refluxing is continued. If the test material contains beta lactose crystals, the solution will become turbid in about 2 to 3 minutes. If the solution remains clear at the end of 10 minutes, the absence of beta lactose anhydride crystals is indicated. If the first sample tested does not induce crystallization at the end of 10 minutes, another sample can be added and the process continued until a sample is encountered which induces crystallization. After beta crystallization has been induced, it is necessary to reestablish the state of beta supersaturation. This is done by pouring down through the condenser the 20 ml. of water in the graduate. This dissolves the beta crystals in the flask. Again 20 ml. of water is distilled off, and the solution is then ready for further tests. The same solution can be used for about 2 hours. When a number of samples are to be tested, a battery of two or more testers may be operated at once. The testing can be shortened further by adding material from two or three samples at once to each flask. If at the end of 10 minutes crystallization is not induced, the absence of beta crystals in all of the samples is indicated. If crystallization is induced, then the samples must be re-tested individually to identify the specific ones containing beta crystals.

APPLICATIONS

Lactose. This method was first developed for testing products made in a study of methods of preparing beta lactose, particularly in relation to the importance of seeding, temperature, and the rate of removal of water from the solution as influencing the character of the product obtained.

It is difficult to prepare beta crystals entirely free from alpha crystals. The reason for this is that the beta lactose is crystallized from solution. The last trace of mother liquid or of the solution of lactose in the wash water adheres to the surfaces of the beta crystals. When the last bit of water is removed by drying, the water is removed faster than the forms can change and crystallize; consequently the solution becomes supersaturated with respect to both the alpha and the beta form, and they both crystallize out together on the surface of the beta crystals. Seeding tests, optical rotations, and moisture tests have indicated that this is true. A similar crystallization was found to occur on the surface of alpha lactose hydrate crystals. A ber of samples of commercial alpha lactose hydrate were tested and all gave tests indicating the presence of beta crystals. If, however, crystals were moistened with a little water before being added to the solution, crystallization was not induced. This small amount of water dissolved the beta crystals present on the surface of the alpha crystals before they were added to the supersaturated beta solution, and consequently crystallization was not induced. This demonstration of the presence of beta lactose crystals on the surface of ordinary alpha hydrate crystals raises an interesting point as to the purity of the alpha lactose used by investigators.

Dried milk. The samples tested included milk dried by the pressure and centrifugal spray, the vacuum and open roll, and the flake and old Campbell processes. In the nearly one hundred tests which have been run on freshly prepared products and products even ten years old which have been maintained at a low moisture content, the tests for beta lactose crystals have been negative.

If, however, the dried milk has been allowed to take up moisture and cake, the tests for beta lactose are usually positive. The lactose glass of the dried milk is diluted by the absorption of moisture to a concentration at which crystallization can occur; and since the solution is highly supersaturated with respect to both the alpha and the beta forms, under some conditions of time and moisture content both the alpha hydrate and the beta anhydride crystallize out together at room temperature.

Dried whey. Most of the methods of drying whey yield products in which beta crystals are absent. This includes: (1) the ordinary spray drying (glass); (2) partial drying by spraying (glass), maintenance of the product in a moisture-reinforced atmosphere (glass to alpha hydrate) followed by further drying; (3) spray drying (glass), rewetting, holding (glass to alpha hydrate) and finally redrying; and (4) evaporation to high

solids content, withdrawing from the evaporator, holding for several hou (supersaturated solution to alpha hydrate) and finally drying by tunn methods. The greater hygroscopic properties of the dried whey probably accounts for the failure of the beta form to crystallize on caking in a similar manner to dried milk.

A new procedure for atmospheric roll drying has recently been developed which is continuous, does not involve a holding period, and results in a product in which the lactose is present largely as beta crystals. All samples of this product tested gave positive seeding tests for beta crystals.

Ice cream. A number of samples of ice cream were tested and none of them gave a positive test for beta crystals.

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PHYSICAL STATE OF LACTOSE AS INFLUENCING THE DETERMINATION OF MOISTURE IN DRY MILK PRODUCTS BY THE TOLUENE DISTILLATION METHOD

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INTRODUCTION

The measurement of the volume of water removed from a product by suspending it in an oil or an organic liquid which is immiscible with water, heating above the boiling point of water, distilling, and condensing the water, is frequently the most satisfactory method for the determination of moisture. In some procedures the liquid used is a nonvolatile oil the temperature of which is maintained considerably above the boiling point of water. This method is unsuitable for materials which decompose at the high temperatures necessary for the rapid removal of the water. Therefore a liquid with a boiling point slightly above that of water is selected, and both water and the immiscible liquid are distilled together, the lower temperature reducing decomposition by heat and the volatilization of the immiscible liquid aiding in sweeping out the water vapor. The vapors are condensed, the water is trapped out and measured, and the immiscible liquid is returned automatically to the distilling flask for redistillation. A method of this type was described by Dean and Stark (3), using xylene (boiling point 138–142° C.) as the immiscible liquid. Bidwell and Sterling (2) substituted toluene (boiling point 111° C.) for xylene, and modified the appara[illegible] slightly to make it more suitable for food products. They used it fo[illegible]e determination of the moisture in a number of products, among the[illegible]ed milk. Jones and McLachlan (6) preferred toluene to benzene o[illegible]ol as the immiscible liquid for the moisture determination on a number [illegible]food products. Wright (13) found the toluene distillation method more suitable than oven drying, for the determination of moisture in dried milk, and recommended a two-hour distillation time. The toluene distillation method has since met with general favor for the determination of moisture in dried skimmilk, and has been recommended by the Committee on Methods, of the American Dry Milk Institute (10) (11). Thompson and Fleming (9) made a careful study of the moisture values obtained by the toluene method and the method recommended by the Association of Official Agricultural Chemists (1). The latter consists in drying a 1.0–1.5 gram sample for 5 hours in a vacuum (less than 100 mm.) oven at 100° C., during which time two bubbles per second of dried air are

Received for publication February 17, 1938.

admitted. The toluene distillation method was found to be the more satisfactory by Thompson and Fleming.

Dried skimmilk is half lactose, and investigators have shown a tendency to consider that the removal of moisture from the lactose in dried skimmilk would follow a course similar to the removal of water from crystalline α lactose hydrate. Troy and Sharp (12) and Sharp (8) have shown that the lactose in spray dried, atmospheric roll dried, and vacuum roll dried milk powder is not crystalline but is present as a glass. Crystalline α lactose hydrate is present, however, in milk dried by the flake or old Campbell process, and in milk dried by the other methods after caking. Therefore a study of the removal of the water of crystallization from α lactose hydrate has a direct bearing only on the determination of moisture in these types of dried milk.

Dried whey has recently been produced in which a considerable part of the lactose is present as crystalline β lactose. Therefore the lactose is present in three different physical states in the different types of dried milk and whey, namely: as a glass, as the crystalline α hydrate, and as the crystalline β anhydride. The rate of removal of moisture from lactose is influenced by its physical state.

EXPERIMENTAL

The moisture in a series of samples of dried whey was determined by oven drying. The samples varied in lactose content, in the physical state of the lactose, and in acidity. Dried wheys show the differences in the physical state of the lactose more strikingly than dried skimmilks, because the amount of lactose present is greater. An air oven was used, as well as two types of vacuum ovens which differed in the degree of vacuum and in the method of applying the heat. The time of drying and size of sample were varied. In addition, moisture was determined by the Mojonnier procedure (Mojonnier and Troy (7)) which involves weighing the sample, dissolving it, drying it quickly, and weighing. In this procedure, the lactose is dissolved, and thus all forms are converted to the same physical state and dried as a glass. We found it difficult to get satisfactory duplicates when applying this method to dried whey. Darkening was variable and often considerable when using this method.

Since some of the these samples contained crystalline α lactose hydrate, a sample of about 160 mesh α hydrate was included each time with the other samples. A method, to be satisfactory for all samples, should remove all of the water of crystallization from the α lactose hydrate in order to avoid difficulties in checking and agreement between duplicates, and to express the moisture content of the various types of products on a comparable milk solids basis. It will be observed that the removal of the water of crystallization was complete or nearly complete in only a few cases.

Results obtained are reported in Table 1. This table also gives results

TABLE 1

Moisture content of dried whey as determined by several different procedures

Whey sample no.	Total anhydrous lactose in whey	Fraction of total lactose as alpha (anhydrous)	pH	Vacuum oven pressure 1 mm. Central Scientific oven							Vacuum 27 in. Mojonnier		Air oven	Mojonnier dissolved	Toluene
				5 gm. 85° C. 5.5 hrs.	5 gm. 85° C. 22 hrs.	5 gm. 85° C. 41 hrs.	2 gm. 85° C. 17 hrs.	2 gm. 100° C. 3 hrs.	2 gm. 100° C. 16 hrs.	2 gm. 100° C. 16 hrs.	2 gm. 100° C. 5 hrs.	5 gm. 100° C. 15 hrs.	2 gm. 100° C. 15 hrs.	0.3 gm. 100° C. ½ hr.	50 gm. 111° C. 1 hour
	%*(1)*	%*(2)*	*(3)*	%*(4)*	%*(5)*	%*(6)*	%*(7)*	%*(8)*	%*(9)*	%*(10)*	%*(11)*	%**(12)*	%**(13)*	%**(14)*	%***(15)*
1	65.8	93.2	4.8	2.80	4.60	4.98	4.73	4.54	5.35	5.25	7.30	8.05	3.91	4.60	5.1
2	60.8	98.2	4.6	2.20	3.99	5.16	4.04	3.64	6.03	6.06	9.75	13.74	4.53	4.43	4.5
3	63.3	89.6	4.2	3.77	5.21	6.37	5.23	5.10	7.74	7.84	10.54	13.56	5.72	5.42	4.3
4	64.6	90.1	5.0	2.14	4.06	4.82	4.30	3.56	5.04	5.13	5.58	6.93	2.72	4.63	4.5
5	70.9	91.4	5.8	1.58	3.80	4.71	3.96	2.69	4.86	4.86	6.78	8.85	2.56	4.26	3.6
6	58.4	93.2	4.9	2.52	3.86	5.10	3.84	3.82	6.85	7.06	10.61	13.60	5.08	5.24	5.5
7	64.6	22.6	4.5	2.31	2.58	2.80	2.55	2.90	3.65	3.77	7.54	8.36	3.32	2.59	4.2
8	65.8	19.5	4.4	2.08	2.42	2.72	2.47	2.92	3.54	3.64	5.90	8.37	3.19	2.10	2.8
9	60.2	21.1	3.9	2.22	2.65	3.08	2.63	2.75	4.12	4.33	7.41	8.49	3.77	3.04	3.2
10	68.3	24.5	4.3	1.75	1.94	2.13	1.81	1.85	2.63	2.38	3.41	5.43	2.10	1.34	2.3
α lactose hydrate	95.0	100	.....	.82	2.71	4.50	2.86	1.92	4.80	4.95	5.01	5.18	2.22	3.87	4.2

* Duplicates not satisfactory.

** Before shaking during distillation was adopted.

obtained with the toluene distillation method. At the time these tests were made the technique of applying the toluene distillation method to dried wheys was rather unsatisfactory because of the settling out of the product, and burning. Later, when the toluene procedure was modified to give satisfactory results with dried whey, our supply of these samples was exhausted.

The results presented in Table 1 are variable and on the whole are not satisfactory. Moisture as determined by the different procedures does not always arrange the samples in the same order with respect to moisture content. Only in procedures (9), (10), (11), and (12) was the water of crystallization removed satisfactorily from the α hydrate. Some of the samples subjected to procedures (11) and (12) darkened greatly. The darkening was associated with high apparent moisture content. Procedure (9)–(10) was perhaps the best from the standpoint of satisfactory duplicates. Procedure (8) most nearly approaches the A.O.A.C. method, but it does not remove the moisture satisfactorily from the α hydrate. The vacuum was higher and the drying time shorter than in the A.O.A.C. method.

MODIFIED TOLUENE DISTILLATION

The Bidwell-Sterling type of apparatus was used with 50 gram samples and 120 ml. of toluene. Difficulty with burning on the bottoms of the flasks, due to settling, was encountered when the method was applied to dried whey. To prevent settling, the necks of the distilling flasks were firmly clamped to a long board which was suspended horizontally. One end of this board was connected to a motor-driven eccentric which gave a thrust of about $\frac{1}{4}$ inch, and operated at a speed of three or four revolutions a second, shaking the flasks violently during the distillation. Using this procedure, the maximum difference between duplicates rarely exceeded .2%. All of the determinations which follow were carried out using this method. The amount of water removed was measured at 10 minute intervals; the water adhering to the sides of the tube and condenser was loosened with a long wire before each reading. The toluene distillation method has the distinct advantage that the moisture-time relationship can be determined easily. This gives an insight into the factors contributing to the moisture content.

CRYSTALLINE LACTOSE

As expected, the rate of removal of water from crystalline α lactose hydrate depends upon the size of the crystals. This was shown for oven drying, by Herrington (5). It is equally true when the moisture is removed by the toluene distillation procedure, as is shown in Figure 1. Alpha lactose hydrate contains 5% of water of crystallization. A number of samples of dried whey and dried milk which contained α lactose hydrate crystals were suspended in a saturated lactose solution on microscopic slides. A microscopic examination indicated that some of the largest α lactose hydrate

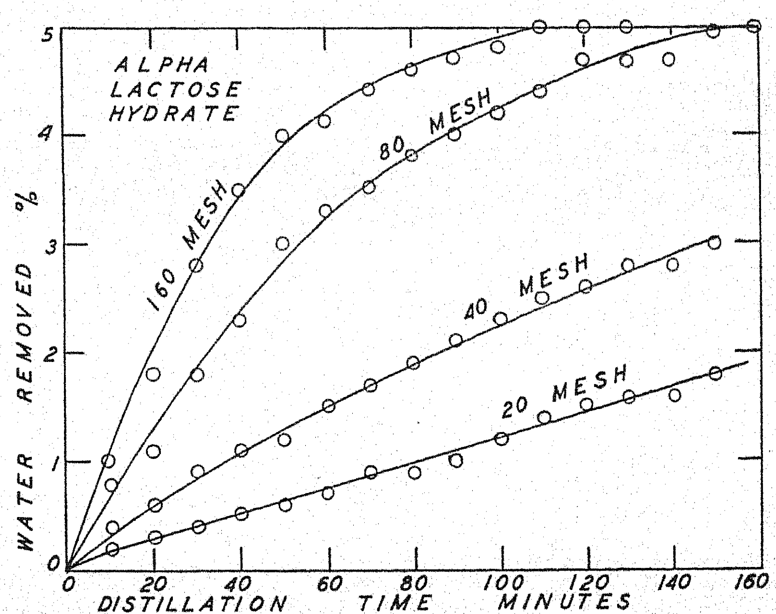

FIG. 1. Effect of the size of α lactose hydrate crystals on the rate of removal of moisture by the toluene distillation method.

crystals corresponded in size to the largest found in the 160 mesh lactose of Figure 1. Thus, a two-hour distillation time would be sufficiently long to remove the water from crystalline α lactose hydrate present in any ordinary dried whey or dried milk. The amount of moisture removed from the crystalline α hydrate increased with each ten-minute increment of distillation time up to 110 minutes for the finer crystals. The curves indicate a slow removal of moisture from the crystalline α hydrate. Pure β anhydride crystals gave no moisture when subjected to two hours of toluene distillation.

DRIED CASEIN

Quantitatively dried skimmilk is mainly an intimate mixture of dried lactose and dried casein. Consequently, moisture-distillation time curves were determined using several samples of dried casein. The results are presented in Figure 2. Here again size of particle was a factor in the rate of removal of moisture. With samples of 60 mesh, the break in the curve is fairly sharp, indicating that most of the moisture is removed in the first 60 minutes. Since the particles of casein are small in dried milk, these results indicate that any pronounced delay in removal of moisture from dried milk could hardly be attributed to the casein. This figure indicates that the toluene distillation method would be satisfactory for the determination of moisture in dried casein.

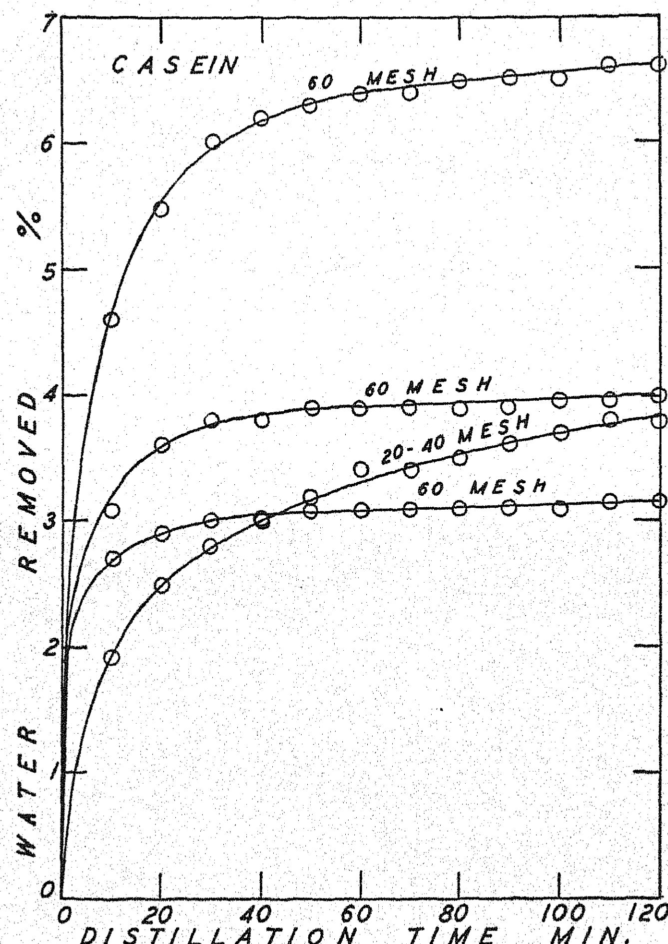

FIG. 2. Moisture content of commercial casein as determined by the toluene distillation method.

DRIED SKIMMILK

Lactose is present in the glass state in the fresh, spray dried, and roll dried skimmilks, and the curves presented in Figure 3, indicate that most of the moisture is removed from these types of dried milk in the first 60 minutes. This result is in agreement with the previous reports (9) (10) (11). For the samples prepared by the flake and old Campbell process, however, 60 minutes of distillation is not sufficient to remove all of the moisture. The shape of the curves is quite different because much of the lactose is present in the form of crystalline α hydrate. Approximately two hours of distillation is necessary for moisture determinations on this type of dried milk.

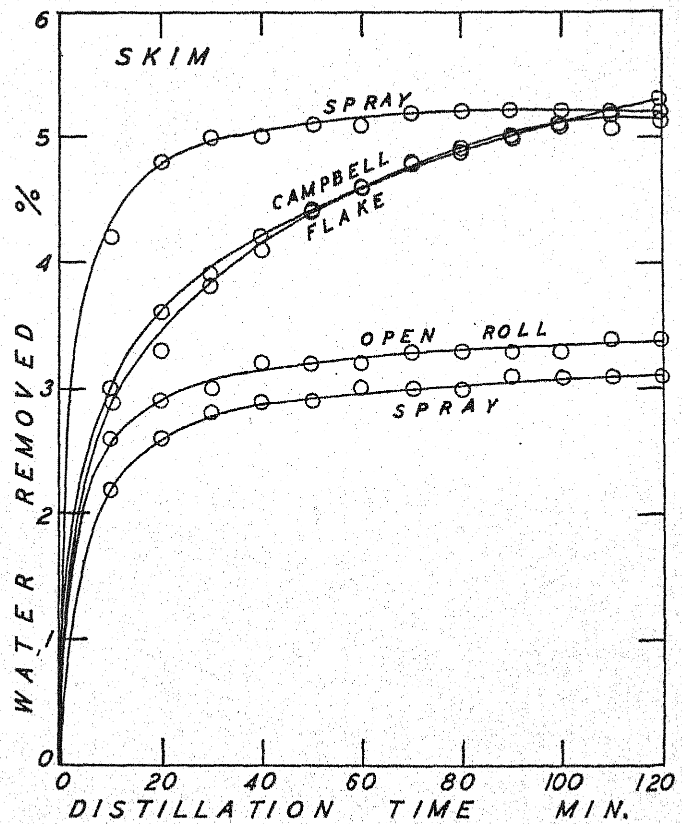

FIG. 3. Effect of the presence of crystalline α lactose hydrate (Campbell and Flake) on the rate of removal of moisture from dried skimmilk. Toluene distillation method.

DRIED WHEY

Typical moisture-distillation time curves for dried whey are given in Figure 4. The curves broke sharply with wheys in which the lactose was present as a glass or as crystalline β anhydride. Practically all of the moisture was removed in 60 minutes. The moisture was removed much more slowly from samples in which the lactose was present as α hydrate crystals, and a two hour distillation time was necessary for a moisture determination. The samples of whey in which the lactose was present as the α hydrate darkened during the distillation, and moisture, perhaps resulting from decomposition, continued to be given off slowly even when the distillation time was prolonged to three hours. The samples in which the lactose was present as a glass or as crystalline β lactose were a light straw color at the end of two hours.

The moisture content of spray dried whey (lactose in the glass state) cannot be determined by the toluene distillation method if the moisture content exceeds 3.5–4.0 per cent. Because of the syrupy state of the lactose,

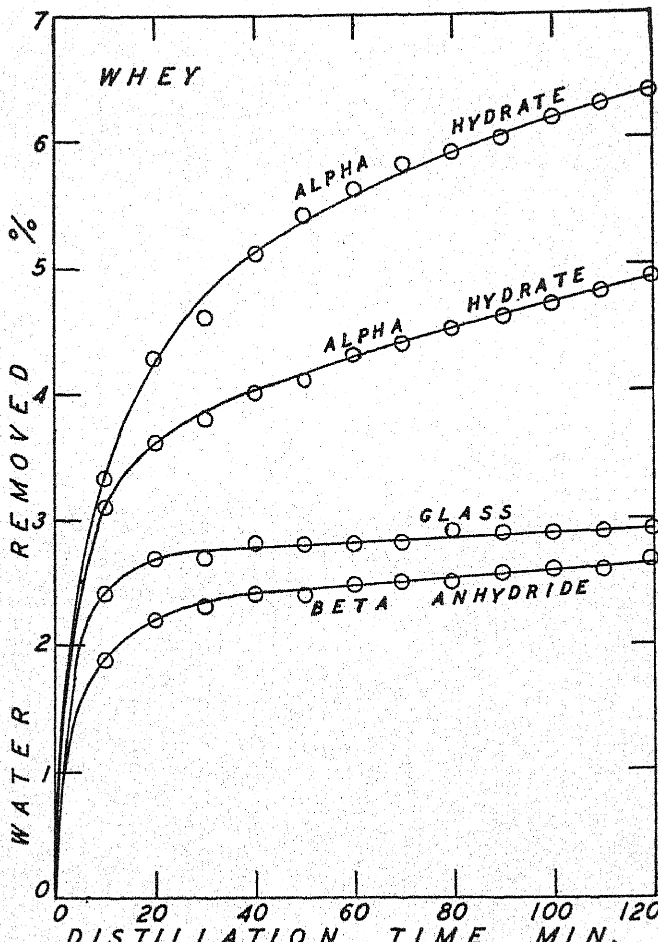

FIG. 4. Effect of different physical states of the lactose on the rate of removal of water from dried whey by the toluene distillation method.

such wheys when heated to the temperature of the boiling toluene form a sticky, doughy mass.

BEFORE AND AFTER CAKING

Troy and Sharp (12) showed that the caking of dried milks which occurs when they absorb moisture is due to the crystallization of the lactose as the α hydrate. In the ordinary spray dried or roll dried products the lactose is present in the non-crystalline state as a concentrated syrup or glass. This glass is very hygroscopic, and it will absorb moisture from atmospheres of low relative humidity. The absorbed moisture dilutes the lactose solution. The particles then become sticky, and in the case of spray dried whey plastic masses are obtained. This dilution of the syrup permits a freer movement

of the molecules and crystallization occurs, mainly as the α hydrate. This crystallization produces a hardening of the mass, which is called caking. After this process has been completed the material may be ground to a fine powder which ordinarily will not cake again and will not become sticky unless exposed to a rather high relative humidity.

Samples of spray dried whey and open roll (previously ground to reduce its bulk so that 50 gram samples could be distilled) and spray dried skimmilk were divided into aliquots and one set was placed for ten days at a relative humidity of 80 per cent. During this time the material took up water, became sticky, and caked. These samples were then held for three days at a relative humidity of 10 per cent. They were then ground, and held at a relative humidity of 20 per cent for two days. Moisture determinations were then made on the aliquots. The results are shown in Figure 5. The aliquots which had not been permitted to absorb moisture gave the relatively sharp breaks in the curves characteristic of such products. The aliquots which had

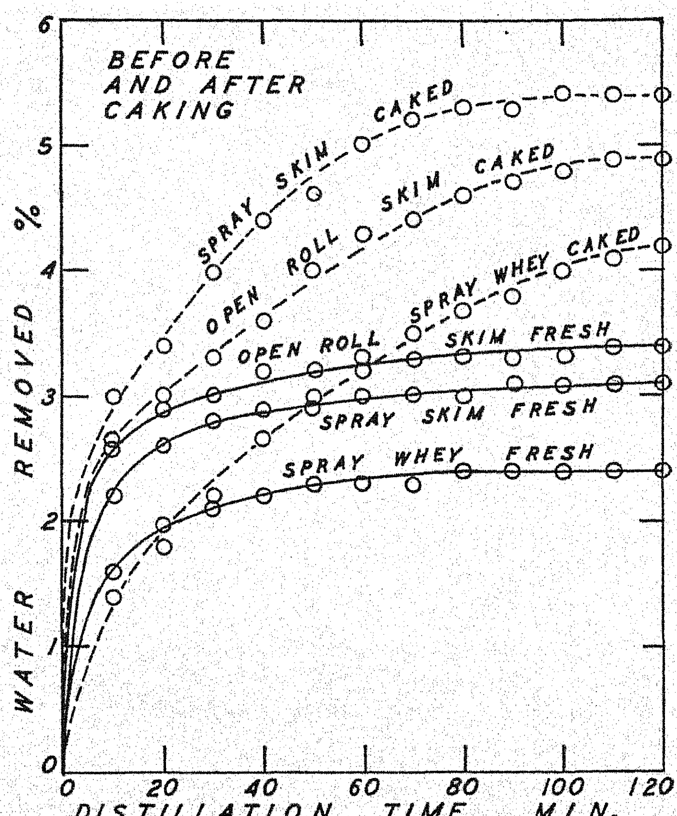

FIG. 5. Effect of previous caking on the rate of removal of moisture from dried milk and dried whey by the toluene distillation method.

gone through the caking process gave curves characteristic of products containing crystalline α lactose hydrate, and similar to those obtained with the flake or old Campbell process dried skimmilk and similar types of dried whey.

DISCUSSION

The determination of moisture in most food products is arbitrary, often to a disconcerting degree, and results which check are obtained only when the complete details of the method are adhered to rigorously. In oven drying the position of the samples in the oven, as well as the number of samples run at one time, often influences the results. Several different moisture-holding or yielding materials are present in many products and the moisture is held by several different mechanisms. In the removal of moisture by dry heating, it is often difficult to tell when a change from one moisture-holding mechanism to another occurs, and when what might be called the "true" moisture is removed without at the same time producing a change in weight of the product and the formation of water due to chemical decomposition.

The main moisture-holding materials in dried skimmilk are the proteins, principally casein, the salts, and the lactose. All of these materials have somewhat different water-holding properties. The water is apparently removed fairly readily from the casein if it is present in a fine state of division. The removal of water from the salts present in dried skimmilk probably involves no difficulty, but the salts present in dried whey, particularly whey which has previously undergone lactose fermentation or which has been highly acidified before drying, may exert a definite influence on the moisture determination. The fermentation products alter the water-holding capacity and the extent of decomposition during the heating.

The amount and physical state of the lactose exerts a marked influence upon the rate of removal of moisture. In order to make a true comparison of the different types of dried milk and dried whey on the basis of their content of milk constituents, the water of crystallization should be removed in the moisture determination from those products containing crystalline α hydrate. If the lactose is present as a glass, the methods for determination of moisture do not remove quite all of the moisture, but they reduce the moisture content of the glass to a constant, very small amount (4) (12).

Great variations in apparent moisture content resulted when samples of wheys of different characteristics were dried by heating in ovens. The degree of pressure reduction exerted a marked effect upon the results. As the pressure was reduced, the apparent moisture content increased, passed through a maximum, and then decreased again at very low pressures. These results mean that the so-called degree of vacuum under which the samples are dried has a marked effect upon the apparent moisture content, particularly of some types of whey, and makes drying by vacuum oven procedures uncertain unless the pressure in the drying oven is accurately controlled to specific,

preferably very low values. A.O.A.C. method simply says less than 4 inches (100 mm.).

The method of applying heat to the sample in the vacuum oven also influences the rate of removal of moisture. In one oven used, the sample was heated largely by radiation, in another type, by conduction. Experience indicates that the apparent moisture contents are higher in the oven in which the heat is transmitted by conduction.

Accurate moisture loss-time curves are not easily obtained by oven drying. Moisture-time curves are important because they give an indication of the properties of the material from which moisture is being removed.

The toluene distillation method was more satisfactory than oven drying for the determination of the moisture in dried whey. The equipment required is relatively simple and cheap. The method is readily adapted to control laboratory or plant use. Large samples are used. Duplicate results usually check within .1 per cent. Furthermore, distillation time curves are readily obtained which reveal the characteristics of the materials from which moisture is being removed. In adapting the toluene distillation method to the determination of moisture in dried whey, violent shaking during the distillation was found to be necessary for satisfactory results.

SUMMARY

1. Dried skimmilk and dried whey containing lactose in the crystalline α hydrate form require appreciably longer heating times for the removal of moisture than do similar products containing the lactose in the glass or crystalline β anhydride form.

2. Determination by oven drying, of the moisture content of different types of dried whey, presents considerable difficulty due to the differences in acidity, amount of fermentation products, per cent and physical state of the lactose, and method of heating and degree of vacuum in the oven.

3. The toluene distillation method possesses distinct advantages for the determination of the moisture in dried milk, dried whey, and dried casein. The moisture loss time relationship can be determined without interrupting the process or interfering with the determination. The moisture loss time relationship indicates the completeness of removal of moisture, and often indicates whether more than one mechanism is involved in the loss of moisture.

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THE EFFECT OF GELATIN ON THE CURD TENSION OF MILK

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Early in 1932 we attempted to find a method whereby a soft curd milk for use in infant feeding could easily be obtained at low cost. At that time natural soft curd milk was available in relatively few sections of the country; moreover, the expense of production placed it beyond the means of many. Our work on the modification of milk had several interruptions, but has now been resumed. While some phases of the subject require further investigation, the results thus far are, we feel, of sufficient interest to warrant publication at the present time.

No attempt will be made here to review the various methods of producing soft curd milk. Most of them possess, however, certain disadvantages. Milk which has been rendered soft curd by special processes, such as homogenization, can be obtained with difficulty or not at all by those living in isolated sections of the country. In addition, the possibility exists that soft curd milk, in which the calcium equilibrium has been altered by the zeolite treatment, may have a calcium content below the optimum for that required by those infants whose mechanism for the utilization of calcium is inefficient. The energy value of natural soft curd milk is low. Weisberg, Johnson and McCollum (11) and Hill (6) reported that natural soft curd milk contained less casein, calcium and phosphorus than hard curd milk. Berry (1) found that rats showed larger gains in body weight on a hard curd milk, which had been rendered soft curd by viscolization, than on a natural soft curd milk.

In view of these facts, it would seem highly advantageous to find a method for the preparation of soft curd milk by the addition of some easily procurable substance which would in itself add to the nutrient value of the milk. The use of cereals, such as barley flour, which have been employed in infant feeding, is prohibited in cases of infants with low carbohydrate tolerance. The fact that breast milk, which has a low curd tension, has a much higher albumin: casein ratio than does cow's milk, suggests the use of a soluble protein in the preparation of soft curd milk. In the pages that follow we will describe some of our experiments on the effect of gelatin on the curd tension of milk.

THE RELATION BETWEEN CURD TENSION AND THE CONCENTRATION OF PROTEIN IN MILK

A. *Casein*

The hardness of the curd formed in the clotting of milk must obviously bear some relation to the concentration of the casein in that curd. But, in a

Received for publication January 15, 1938.

system as complicated as milk, several other components must exist which exert more or less influence on the character of the curd. It is clear, therefore, that in order to determine the exact relationship of the curd tension to the concentration of the casein, both the nature of these other components as well as the extent of their influence must be known. Even though an attempt is made to maintain a fairly constant concentration of these components in the milk, the results will at best give one but a rough idea as to the extent of the dependence of curd tension on casein concentration.

The casein content of several samples of raw whole milk[1] was determined by the official method (8). The milks were all obtained from Guernsey or Jersey cows, except in a few cases of soft curd milk, where a pooled sample was used. The sealed bottles containing the milk were packed in ice and sent from the dairy farms in New Jersey or New York State to our laboratory in New York City. The curd tension of these same milks was determined by the method of Hill (5). The concentration of pepsin was constant in all the experiments in which curd tension was determined; the addition of the large quantity of calcium chloride in the coagulation probably resulted in a fairly constant concentration of calcium ions, while the high buffer capacity of the system helped to keep the concentration of hydrogen ions within rather narrow limits. Our results, as well as those of Morris and Richardson (7), of Weisberg, Johnson and McCollum (11), and of Doan and Welch (3) are

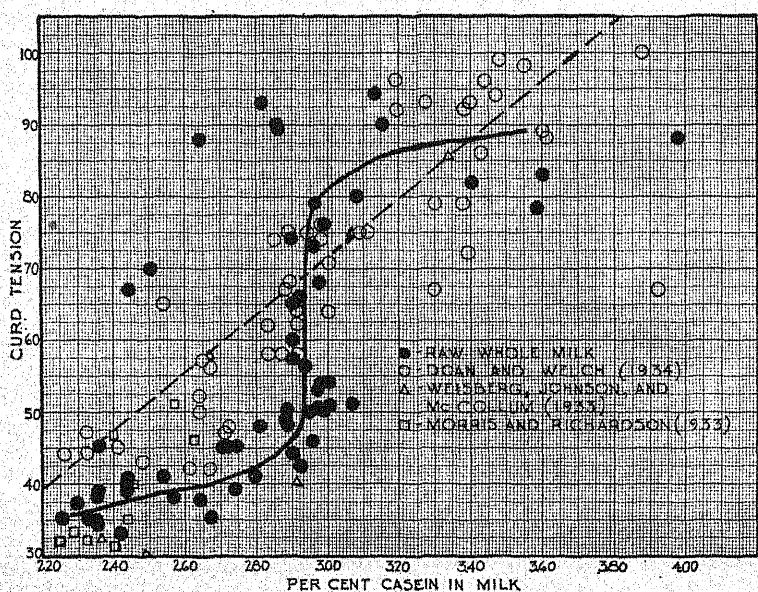

FIG. 1. Relation between the concentration of casein and the curd tension of milk.

[1] We wish to thank the Sheffield Farms Company for supplying the milk used in part of this research.

shown in Figure 1. Most of the results of Espe and Dye (4) fell outside the limits of curd tension in the figure. The variation in the curd tension of different milks with approximately the same concentration of casein shows clearly the influence of other factors in the coagulating system. A large number of our points, however, appear to describe an S-shaped type of curve. The straight line was drawn from the Doan and Welch equation (3), which relates curd tension to casein concentration. Our values seem to follow the S-shaped curve rather better than the straight line.

In most of the milk samples thus far investigated a high curd tension is accompanied by a high casein concentration, and a low curd tension is found in milks with a low casein concentration. However, wide variations in curd tension occur in milks with the same concentration of casein. Further investigation is necessary before the exact relation between curd tension and casein concentration can be ascertained.

B. *Gelatin*

It has just been shown that in a large number of cases the curd tension of milk increases with increasing concentration of casein. The effect of a soluble protein, gelatin, on the curd tension of milk will now be described.

The gelatin used in this work, unless otherwise noted, was a sample of Knox Gelatine.[2] The milk samples were the same as those described in the preceding section. The gelatin was weighed into the regular test jar, 100 cc. of milk at room temperature was introduced, and the mixture was allowed to stand for a few minutes until the gelatin was thoroughly soaked. The jar was then placed in a water bath at 60° C. and the contents were stirred until the gelatin was dissolved. The mixture was then allowed to stand at room temperature with occasional stirring until the temperature reached 35° C., when the curd tension was determined by the method of Hill. Milk, which contained no gelatin but which was subjected to the same conditions of heating, exhibited the same curd tension as the unheated milk. The results are given in Figure 2.

Each of the curves represents the average values obtained over a range of about 10 grams of curd tension; thus, the curve which begins at a curd tension of 45 grams is the average of all the results for milks with an initial curd tension between 41 and 50 grams. The curves illustrate in striking fashion the lowering of the curd tension of milk by gelatin. If a curd tension of 33 grams or lower is taken to represent a soft curd milk, then, in general, milks with an initial curd tension up to about 50 grams are converted into soft curd milks by the addition of two per cent of gelatin, while those with an initial curd tension up to about 70 grams are rendered soft curd by the addition of four per cent of gelatin. Most of the samples of

[2] Bone gelatin: pH 6.1, viscosity 61, jelly strength 200.

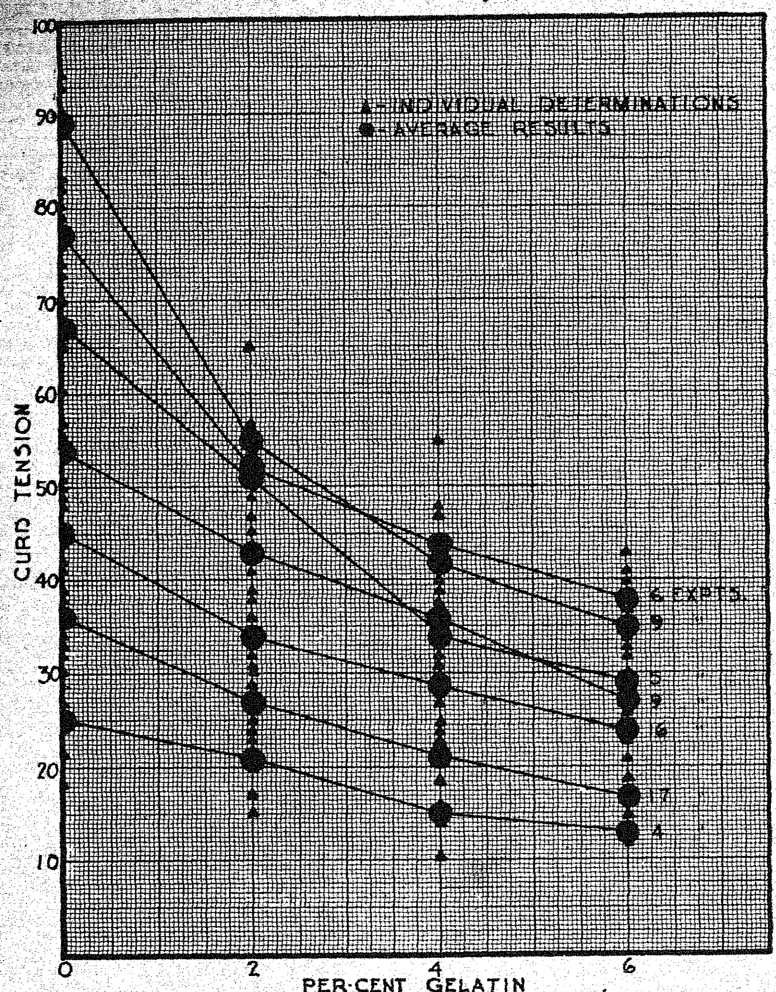

Fig. 2. Effect of gelatin on the curd tension of milk.

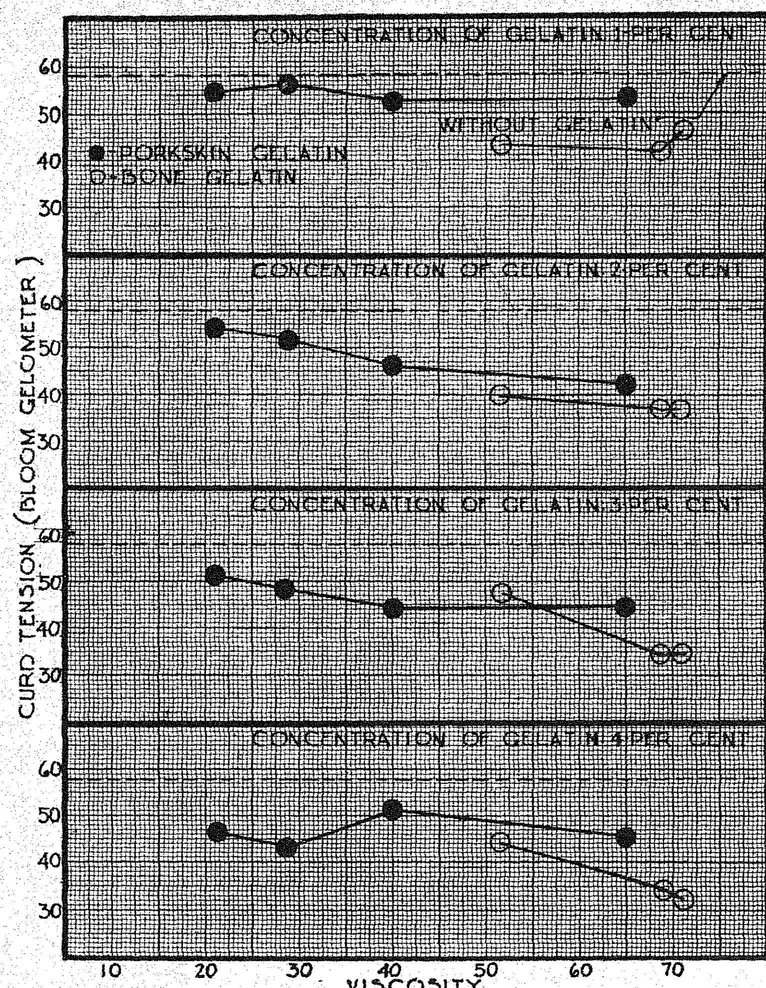

Fig. 3. Relation between curd tension and the viscosity of the gelatin.

milk, which we have purchased in the open market in New York City and elsewhere have had curd tensions below 50 grams.

The percentage reduction in curd tension by different concentrations of gelatin is shown below in Table 1.

TABLE 1

Percentage reduction in the curd tension of milk by gelatin

Range of initial curd tension	Average percentage reduction in the curd tension of milk by gelatin of the following concentrations		
Grams	2 per cent	4 per cent	6 per cent
18–30	14	37	44
31–40	27	41	54
41–50	25	35	47
51–60	21	34	49
61–70	24	49	57
71–80	32	42	50
81–94	38	53	60

In general, the percentage reduction in the curd tension of milk by two per cent of gelatin is greater for a hard curd than for a soft curd milk. The addition of the first two per cent of gelatin to the milk brings about a greater percentage reduction than do subsequent additions of two per cent of gelatin. The addition of six per cent of gelatin to milk reduces the curd tension to about one-half of its original value.

The above experiments show clearly that gelatin is very effective in reducing the curd tension of milk. But when these experiments were repeated with a sample of bulk gelatin from the hospital kitchen the reduction in the curd tension of milk was much smaller. In the literature the statement is occasionally found that gelatin has no effect on the curd tension of milk. This would indicate that all gelatins are not equally effective in reducing the curd tension of milk.

Riggs and Beaty (9) at a meeting of the American Chemical Society in New York City in 1935 reported that the lowering of the curd tension of milk by gelatin was related to the viscosity of the gelatin sample employed; *i.e.*, the higher the viscosity of the gelatin the greater the reduction in curd tension.

We have been extremely fortunate in having placed at our disposal seven different preparations of gelatin,* some properties of which are listed in Table 2.

The viscosity and jelly strength of these gelatin preparations were determined by the regular methods (10). The pH of a one per cent solution of the gelatin in water was estimated with the glass electrode.

Striking differences are noted in the properties of the porkskin and of

* We are indebted to Dr. Thomas B. Downey for the data on the viscosity and jelly strength of the various gelatins used throughout this investigation.

TABLE 2

The properties of some gelatin preparations used in experiments on curd tension of milk

Number of gelatin preparation	Source of gelatin	Viscosity	Jelly strength	pH
		millipoise		
P–1	Porkskin	65.0	305	3.82
P–2	"	40.2	225	4.05
P–3	"	28.7	139	4.20
P–4	"	21.4	84	4.32
B–1	Bone	51.6	246	6.08
B–2	"	68.7	197	6.14
B–3	"	71.0	166	5.90

the bone gelatin preparations. The porkskin gelatins show a much higher acidity than do the bone gelatins. In the case of porkskin gelatins, viscosity increases with increase in jelly strength, while for the bone gelatins, viscosity increases as the jelly strength decreases.

A study has been made of the effect of these gelatins on the curd tension of milk. A few changes have been introduced in the experimental procedure. The milk samples were obtained from Guernsey cows from a dairy farm about thirty miles from the laboratory. The samples were obtained at the afternoon milking and were kept at a low temperature until used the following morning. The milk was then brought to 25° C., 100 cc. were pipetted into the test bottles, which contained the weighed amount of gelatin, and the mixture was allowed to stand at room temperature for fifteen minutes. The test bottles were closed with a rubber stopper which was provided with a thermometer and a small outlet to allow for the expansion of air during heating. The jars were then transferred to a thermostat maintained at 40° C. and the contents were swirled around two or three times at five minute intervals. At the end of one-half hour the bottles were removed from the thermostat and allowed to stand, with occasional stirring, at room temperature until the temperature of the contents had dropped to 35° C. The curd tension was then determined either with the Hill apparatus or with the modified Bloom gelometer (2).

The results of two of a series of experiments are given in Figures 3–6. The curd tensions shown in Figures 3 and 5 were obtained with the modified Bloom gelometer for varying concentrations of the gelatins in milk, the original curd tension of which was 58 grams. Those given in Figures 4 and 6 were obtained in a similar experiment using the Hill apparatus and a different sample of milk, which also had an initial curd tension of 58 grams. Because of the differences in pH of the gelatin samples (to be discussed in detail below) the curves for the bone gelatin preparations and for the porkskin gelatin preparations have been drawn separately. The results show that within the limit of experimental error the reduction in curd tension

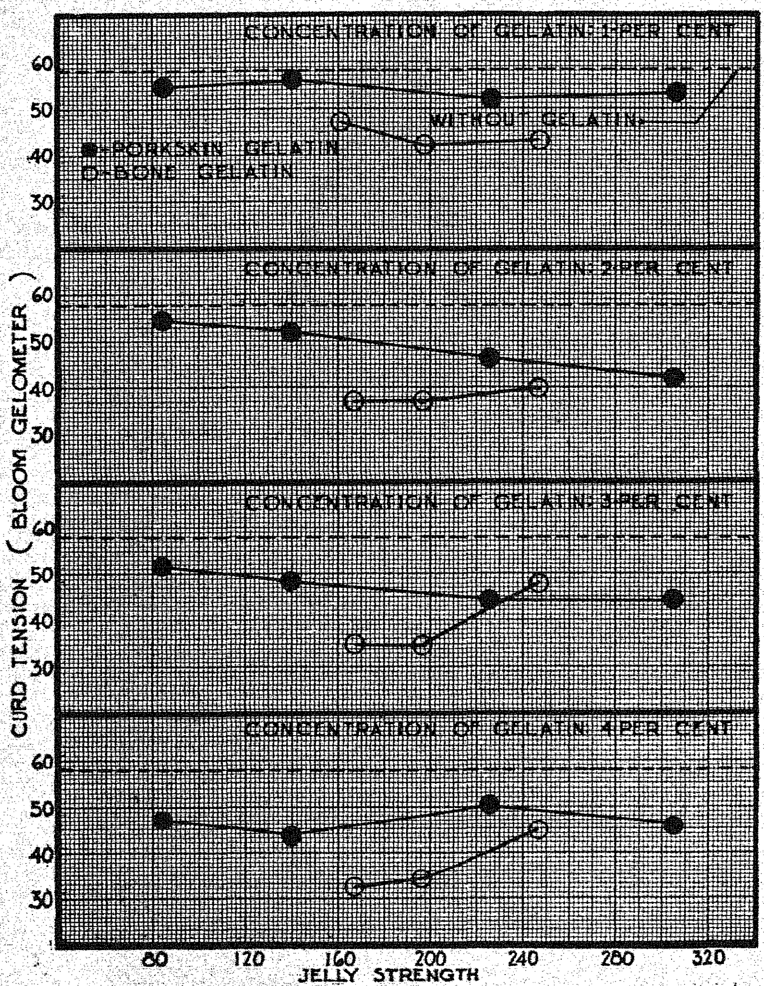

FIG. 4. Relation between curd tension and the viscosity of the gelatin.

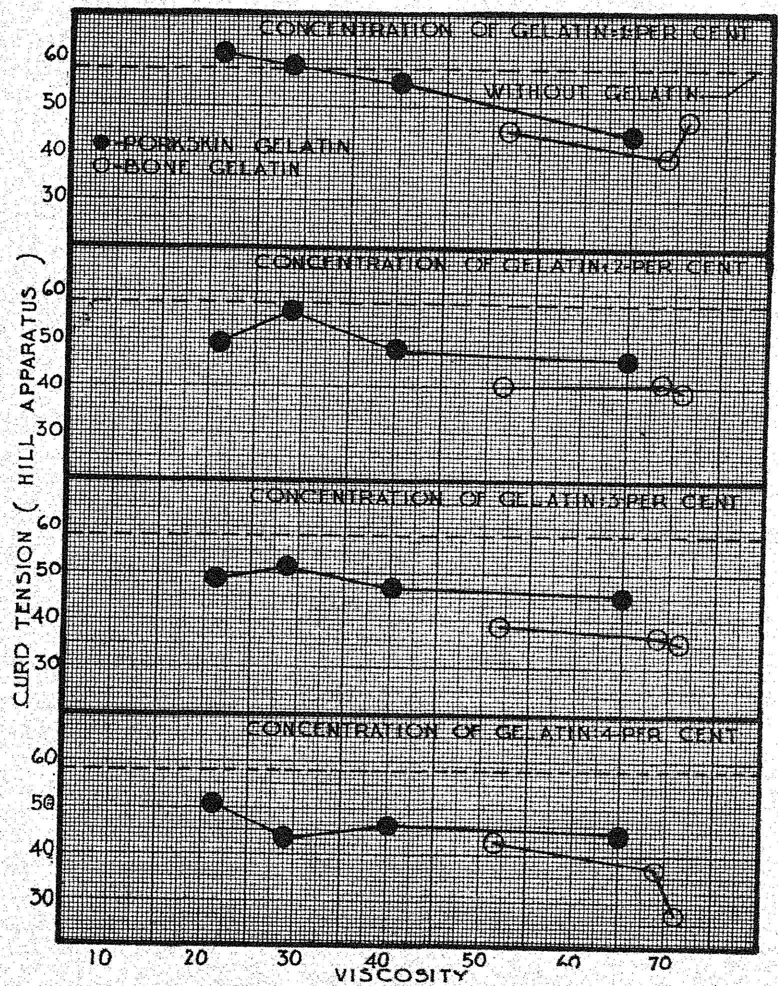

FIG. 5. Relation between curd tension and the jelly strength of the gelatin.

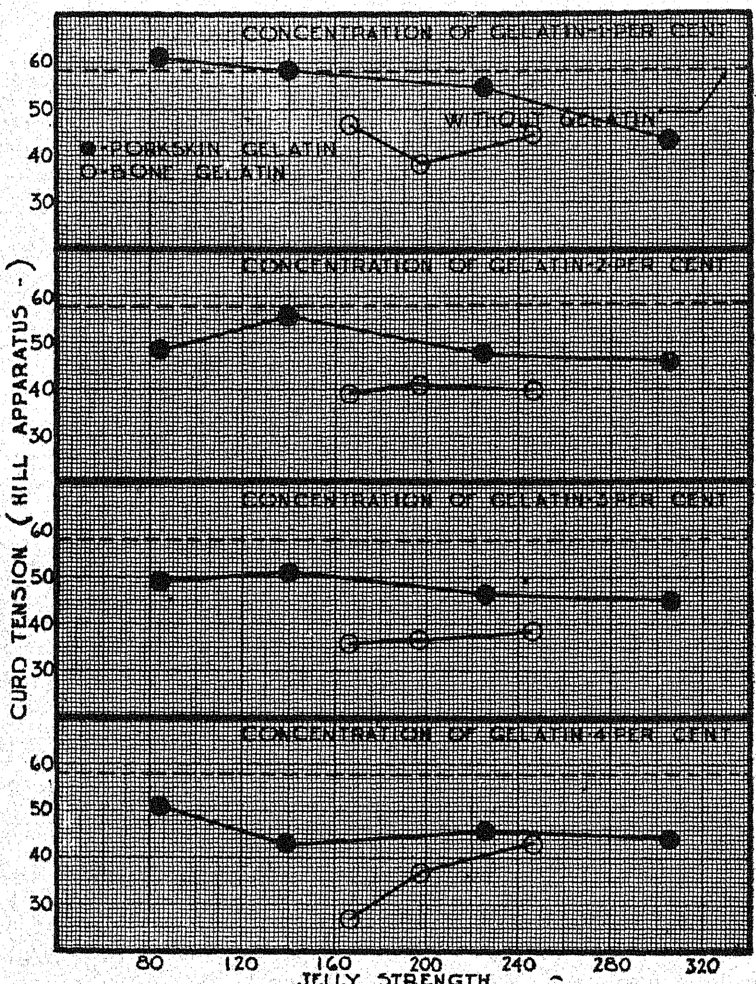

FIG. 6. Relation between curd tension and the jelly strength of the gelatin.

increases with increase in the viscosity of the gelatin preparation employed. If the reduction in curd tension is compared with the jelly strength of the gelatins, however, the two types of gelatin show a different behavior. With increase in jelly strength the reduction in curd tension increases in the case of the porkskin gelatins and decreases in the case of the bone gelatins. The most effective gelatin from the standpoint of reduction of curd tension was a bone gelatin with a high viscosity and a low jelly strength; the least effective, a porkskin gelatin with a low viscosity and a low jelly strength.

The percentage reduction in the curd tension of milk by the bone and by the porkskin gelatins is given in Table 3. The results are the average of six experiments on milks with initial curd tensions between 34 and 58 grams.

TABLE 3

Percentage reduction in the curd tension of milk by various types of gelatin

Gelatin number	Viscosity of gelatin	Average percentage reduction in the curd tension of milk by gelatins of the following concentrations			
		1 per cent	2 per cent	3 per cent	4 per cent
	millipoise				
P-4	21.4	6	14	17	21
P-3	28.7	5	12	21	28
P-2	40.2	10	18	29	25
P-1	65.0	17	22	28	24
B-1	51.6	21	33	31	30
B-2	68.7	30	37	44	41
B-3	71.0	24	39	44	48

In nearly every case an increase in the reduction of the curd tension follows an increase in the viscosity of the gelatin sample from the same source. However, if the gelatin samples are considered, irrespective of source, the P-1 gelatin is seen to occupy an anomalous position; *i.e.*, the reduction in curd tension is less than would be predicted from its viscosity. The extremely high jelly strength of the P-1 gelatin may explain this behavior, in part, at least; incipient gel formation during coagulation of the milk would tend to raise the curd tension reading and so lead to erroneous conclusions regarding the reduction in curd hardness. This effect would be greater the higher the concentration of gelatin in the milk.

These experiments explain why investigators working with one per cent solutions of gelatins similar in properties to P-3 or P-4 would fail to obtain a marked lowering of the curd tension of milk.

THE RELATION BETWEEN CURD TENSION AND THE CONCENTRATION OF HYDROGEN IONS IN MILK

In the early part of our investigation we studied the effect of the pH on the curd tension of milk alone and of milk to which had been added five per cent of gelatin (Knox Gelatine). Pasteurized milk was used in this work. A measured amount of 0.1400 N hydrochloric acid or of 0.1094 N sodium hydroxide was added in a fine stream from a burette to 100 cc. of milk. The mixture was rotated constantly during the addition to prevent any local excess of reagent. In the case of milk containing gelatin, the gelatin was first dissolved in the milk before the addition of the acid or the alkali. The pH was determined with the quinhydrone electrode. The curd tension was estimated by means of the Hill apparatus. The results are given in Figure 7.

The initial curd tensions of the milks varied from 17 to 43 grams. The curves represent approximately the average curd tensions of the milks at the various pH values. Nine complete titrations were performed on milk alone and six on milk with added gelatin. The pH was found to have a very marked effect on the curd tension. In the case of milk alone the average

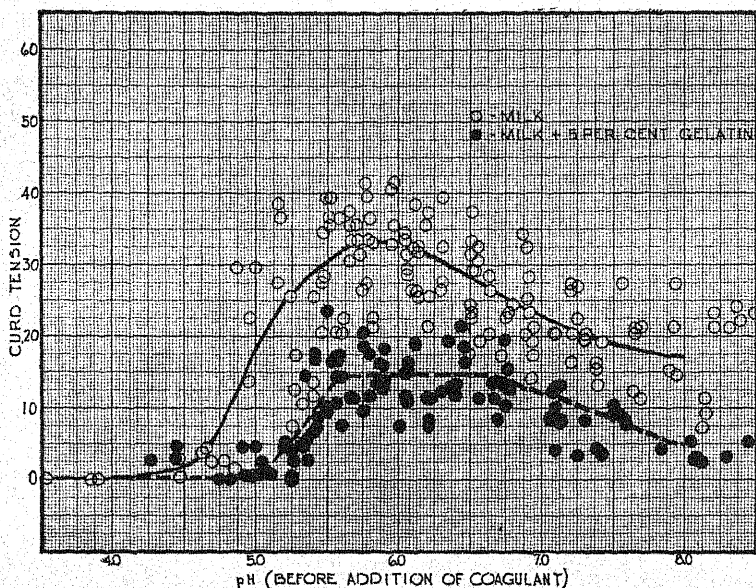

FIG. 7. Relation between curd tension and the pH of the milk.

curd tension curve reached a maximum at a pH of about 5.7 to 5.9. Beyond this point the decrease in curd tension with increasing acidity was probably due to the removal of the casein from colloidal solution by precoagulation with acid, which left less and less of the protein to react with the pepsin. The fall in curd tension on the alkaline side of the maximum was due, in part at least, to the inactivation of pepsin by the alkali. The average curd tension curve for the milk which contained five per cent of gelatin is striking in that here we do not have a maximum point, but rather a maximum zone which extends from approximately pH 5.6 to 6.6. Since the pH was determined with the quinhydrone electrode, no attempt was made to extend the curves beyond pH 8.

The addition of five per cent of the gelatin to the milk changed the pH on an average from 6.57 to 6.35. Such a pH change would in itself result in only a very slight increase in curd tension.

As has already been noted, a marked difference in acidity existed between the bone gelatin preparations and the porkskin gelatin preparations used in the present investigation. The effect of these gelatin preparations on the pH of the milk is shown below in Table 4. The pH values recorded here were estimated by means of the glass electrode.

Addition of two per cent of the various gelatins increased the acidity of the milk, the porkskin gelatins having a somewhat greater effect. After coagulation, however, the pH of the coagulated milk which contained two per cent of bone gelatin was the same as that of the coagulated milk to which

TABLE 4

The effect of various gelatins on the pH of milk

Gelatin number	pH of original gelatin preparation	pH of a 2 per cent solution of gelatin in milk	
		Before addition of coagulant	After addition of coagulant
P–1	3.82	6.06	5.39
P–2	4.05	6.04	5.42
P–3	4.20	6.08	5.47
P–4	4.32	6.13	5.45
B–1	6.08	6.28	5.60
B–2	6.14	6.29	5.60
B–3	5.90	6.29	5.57

pH of original milk, before coagulation: 6.47
after coagulation: 5.60

no gelatin had been added, while the pH of the milk which contained the porkskin gelatin was slightly more acid. It is doubtful whether this change in acidity is large enough to cause any marked difference in curd tension; yet since slight differences do exist, it seems advisable at the present time to consider the two types of gelatin separately.

SUMMARY

In general, increase in the curd tension of milk was accompanied by an increase in casein concentration, although wide variations occurred. The relation of the curd tension to the concentration of the casein seemed to follow approximately an S-shaped curve.

The addition of gelatin (Knox) to milk caused a marked fall in curd tension. In most cases, two per cent of gelatin added to milks of curd tension up to about 50 grams converted them to soft curd milks.

The reduction in the curd tension of milk increased with increasing viscosity of the gelatin preparation employed. As the jelly strength of the gelatin preparation increased, the reduction in curd tension increased for the porkskin gelatins and decreased for the bone gelatins.

A bone gelatin with a high viscosity and a low jelly strength was most effective in lowering the curd tension of milk.

The pH was found to have considerable influence on the curd tension. The average curd tension of milk reached a maximum when the pH of the milk before coagulation was between 5.7 and 5.9. In the case of milk which contained five per cent of gelatin, the average maximum curd tension occurred when the pH before coagulation was between 5.6 and 6.6.

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THE LIPASE, FATTY ACID AND CHOLESTEROL CONTENT OF COW'S BLOOD IN RELATION TO THE PRODUCTION OF RANCID MILK

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In a study of off-flavored milk (4) (5) (6), significant differences were found between the composition of normal and that of rancid milk produced by animals of the same breed while maintained under the same nutritional and environmental conditions. Rancid samples were lower in lactose and higher in chloride, fat, total solids, protein, titratable acidity and hydrogen-ion concentration than were normal samples obtained during same period of lactation. Of perhaps even greater significance, the lipolytic activity of rancid milk was found to be greater than that of normal milk.

The increased lipase content of rancid milk has come to be regarded as one of the causes, if not the sole cause of natural rancidity. The flavor of rancid milk is attributed to the presence of free fatty acids, an unusual amount of which is thought to be released as a result of the increased amount of lipase. It has been suggested, however, that other factors may contribute to the production of rancidity. There is the possibility of the presence in milk of some substance which acts either as an activator or an inhibitor of lipase activity and which may be present in larger or smaller amounts in rancid milk than in normal milk. Cholesterol suggests itself in this role; it is a normal constituent of milk and has been shown to exert an effect upon lipase activity. The exact nature of its influence, however, appears to be a matter of disagreement. Remezov and Tavaststyerna (7) consider cholesterol an important regulator of serum lipase activity. They found that *in vivo,* cholesterol inhibits blood lipase by adsorption. Later, however, Corran (2) reported that cholesterol in low concentration acts as an augmenter of lipolysis.

Inasmuch as blood is the ultimate source of milk constituents, it appeared possible that the blood of animals producing rancid milk might differ in certain respects from that of animals whose milk is normal. The increased lipase of rancid milk might be due to increased blood lipase; the free fatty acid giving rancid milk its flavor might be the result of elevated blood fatty acids; an unusual amount of blood cholesterol might bring about an unbalance between the cholesterol and lipase of milk, resulting in an abnormal lipolytic activity, with the consequent production of rancid milk. Determinations were therefore made of the lipase, fatty acid and cholesterol content of the

Received for publication February 2, 1938.

blood of certain members of the herd under observation in a study of off-flavored milk. The present paper reports the results of these determinations.

EXPERIMENTAL

The cows used in the experiment were members of the college Jersey herd. The care and management of the herd have been described in detail in a previous paper (4). Milk samples obtained weekly from each member of the herd over a period of three years were scored for flavor and analyzed. Certain of these cows were selected as subjects of the blood study which was continued over a period of nine months. Blood samples were always taken early in the morning, approximately three hours after the cows were fed. The number of samples obtained from the individual animals varied, depending upon the length of time the animal was available for the experiment. In five cases practically complete lactations were covered.

Blood was drawn from the jugular vein into a centrifuge tube and the serum obtained by centrifugation after the clot had formed. The total lipids were determined by the oxidation method of Bloor (1). The fatty acids were calculated by difference after the determination of the cholesterol by the Liebermann-Burchard reaction, following Bloor's procedure. The lipolytic activity of the blood was determined by a procedure which was essentially the same as that employed by McGuire and Falk (3). This method determines the degree of hydrolysis of tributyrin effected by 15 ml. of a 1:1 dilution of serum during a 24-hour incubation period. The lipolytic activity of the serum is expressed as ml. of 0.1 N NaOH required to neutralize the acid released by hydrolysis.

The method used for estimating lipase activity was capable of detecting the presence of 0.5 cc. serum, as may be seen in Table 1 which shows the degree of hydrolysis produced by increasing amounts of serum.

TABLE 1

Degree of hydrolysis of tributyrin effected by increasing amounts of serum

Ml. serum	Degree of hydrolysis ml. 0.1 N NaOH
0.5	0.6
1.0	1.0
5.0	3.3
7.5	4.6

The lipolytic activity of 112 blood samples was determined. Of these, 44 samples were taken on days when the animals produced rancid milk. The blood of animals producing rancid milk was found to effect the same degree of hydrolysis as did that of animals whose milk was normal. The mean titration for the former group was 4.48 ml., that of the latter, 4.41 ml. The

increased lipolytic activity of rancid milk may not, therefore, be explained on the basis of an increased lipase content of the blood.

Since few data are available on the fatty acid and cholesterol content of

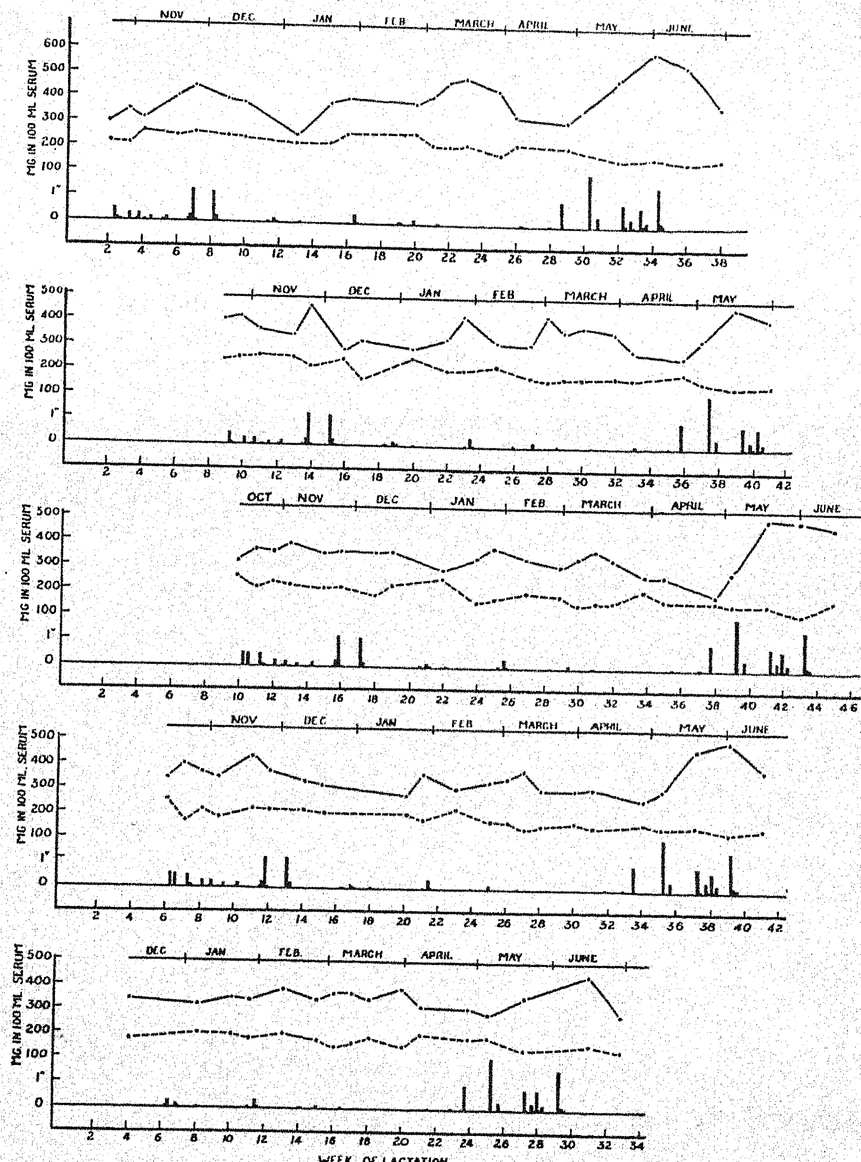

FIG. 1. Variation in the fatty acid and cholesterol content of the blood serum of individual cows during lactation.

——— Fatty acid.
- - - - - Cholesterol.
■ Rainfall.

TABLE 2

Influence of green pasture on the fatty acid and cholesterol content of the blood serum of cows

Animal number	Condition of pasture	Week of lactation	Fatty acids	Cholesterol	Animal number	Condition of pasture	Week of lactation	Fatty acids	Cholesterol
			mg. per 100 ml. serum	*mg. per 100 ml. serum*				*mg. per 100 ml. serum*	*mg. per 100 ml. serum*
1	D[1]	27	349	137	6	D	22	325	221
	G[2]	31	445	159		G	24	503	185
2	D	22	242	153	7	D	35	301	147
	G	26	388	112		G	39	506	131
3	D	17	259	138	8	D	17	315	242
	G	19	454	114		G	20	519	163
4	D	39	289	158	9	D	21	304	205
	G	41	498	171		G	24	507	144
5	D	32	498	171	10	D	22	299	213
	G	34	609	177		G	25	499	177

[1] Dry pasture.
[2] Green pasture.

the blood of lactating cows, individual curves for approximately co
lactations are shown for five cows in Figure 1. Two of these animals,
bers 4 and 5, frequently produced rancid milk. From the graphs it is e
that the trend of the cholesterol content of the blood paralleled that
fatty acids but that changes in the fatty acids were the more pronoı
These constituents tended to increase during the first months of lact
then to decrease gradually as lactation advanced. The most marked v
tion occurred in the months of May and June when the fatty acids show
pronounced increase without a corresponding change in the cholesterol.
marked rise in fatty acids was attributed to the improvement in the pastu
since, as may be seen in Figure 1, it occurred immediately after a period
rainfall which broke a long period of drought. All cows showed the rise i
fatty acids, regardless of the period of lactation. This is shown in Table
which gives the stage of lactation and the fatty acid and cholesterol conte
of blood while the pasture was dry and after it became green.

Monthly variations in the fatty acids and cholesterol of the blood
shown in Figure 2. The graphs in this figure present mean values for
animals under observation. Values have not been included for those peric
when the fatty acid content was increased because of green pasture. T

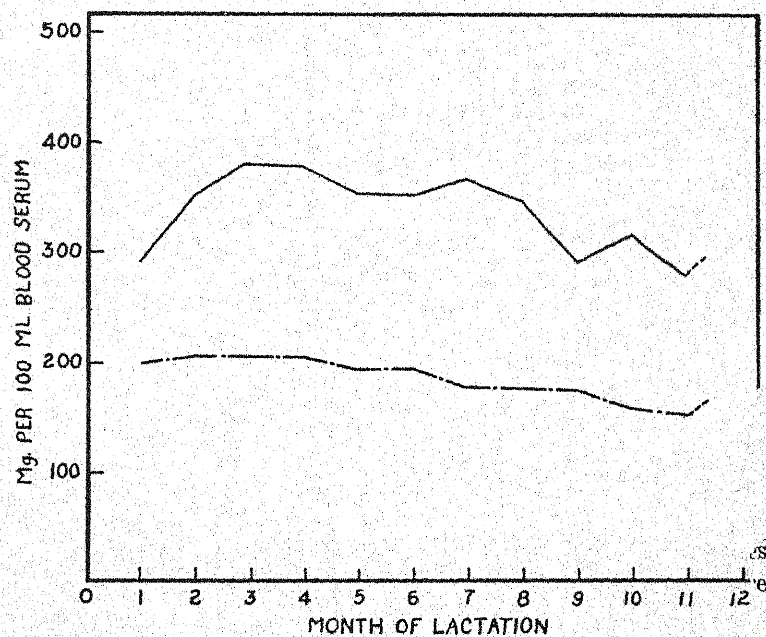

FIG. 2. The average fatty acid and cholesterol content of the blood serum of co
relation to the period of lactation.

——————— Fatty acid.
—— · —— · —— Cholesterol.

cid of blood was marked by a sharp rise during the first 12 weeks of on, a gradual decline during the succeeding 20 weeks, followed by a decline which lasted until the end of lactation. The cholesterol conmained nearly constant for the first 24 weeks, then decreased gradually end of the lactation period.

. total of 248 blood samples were analyzed. In Table 3 are shown the . fatty acid and cholesterol content of all samples taken on days when nilk was normal and the mean values for samples taken on days when ıd milk was produced.

TABLE 3

Mean fatty acid and cholesterol content of blood serum of cows producing normal and rancid milk

Source of samples	Blood samples	Fatty acids	Cholesterol
	number	*mgs. per 100 ml. serum*	*mgs. per 100 ml. serum*
Cows producing normal milk	212	368.3	189.7
Cows producing rancid milk	36	359.7	213.7

It is evident from the table that there was no significant change in the y acid and cholesterol content of the blood of animals on days when rancid : was produced.

Ɔuring the period of the blood study seven cows produced rancid milk. of these animals had a blood fatty acid and cholesterol content higher the average value for the same periods of lactation; the levels for the · five animals closely followed the normal. The mean fatty acid and ›sterol content of all samples of blood from the seven animals which pro-1 rancid milk was 368 mg. and 192 mg. per 100 ml. serum, respectively, .mpared with values of 388 mg. and 202 mg. for animals producing only ıal milk. The differences are not significant.

CONCLUSIONS

mal values for the fatty acid content of the blood serum of cows show increase during the first three months of lactation, followed by a decrease which continues to the end of lactation. The cholesterol of the blood shows a similar but less pronounced rise followed by a ecline. A marked increase in blood fatty acids occurs when lactating .re changed from dry to green pasture. This increase occurs regardless e stage of lactation.

'he fatty acid and cholesterol content of the blood serum of cows producancid milk follows the same trend as does that of cows producing normal : during corresponding periods of lactation. There is no increased lipo-

lytic activity in the blood serum of cows producing rancid milk, althou milk has a greater lipase content than normal milk.

The production of rancid milk cannot be explained on the basis of a in any one of the above blood constituents.

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COFFEE AS A FACTOR IN THE FEATHERING OF CREAM

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The feathering of cream when mixed with hot coffee was first reported upon by Burgwald (1) in 1923. He found acidity of the cream and homogenization to be the most important factors causing this defect. The method of preparing the coffee, according to Burgwald, was not important as the hydrogen ion concentrations of the brew made by boiling, percolating and by the drip method were practically identical (4.91–4.92). Burgwald further stated that there was no difference in the effect of the various grades of coffee upon feathering. The method of combining the coffee and cream was of no great consequence although the cream feathered at a slightly lower acidity when the coffee was added to the cream and sugar mixture.

In 1930 Tracy and Ruehe (2) showed that the feathering of homogenized cream in coffee was closely related to the salt balance in the cream and coffee mixture. An excess of calcium or magnesium salts in either the cream or water used for making the coffee increased the tendency for the cream to feather. Cream high in acidity and that high in butter fat were found to be rather unstable. Lowering the fat content, reducing the acidity, increasing the serum solids, the addition of citrate salt, preheating and homogenizing at a high temperature, reducing the homogenizing pressure, and the use of two homogenizing valves instead of one, were factors found to reduce the tendency towards feathering through their effect in reducing fat clumping.

The work of Doan (3) substantiated the findings of Tracy and Ruehe. Whitaker (4) in studying the feathering of evaporated milk in coffee found that the milk was more likely to feather in strong than in weak coffee. Furthermore he found that the hydrogen ion concentration of the coffee remained constant and was independent of the method of preparation. Prolonged contact of the coffee and grounds, however, were shown to increase the quantity of soluble ash and consequently tended to increase feathering.

PLAN OF STUDY

In order to obtain a better understanding as to what part coffee may play in the problem of cream feathering, samples of coffee were secured from a number of different processors and distributors. Altogether samples of twenty-six brands were obtained for this purpose. These coffees were compared from the standpoint of:—

1. Relative tendencies towards feathering.
2. Comparison of different methods of making coffee in relation to feathering.

Received for publication March 4, 1938.

3. Significance of amount of coffee used.
4. Relation of coffee species, degree of roast and method of curing to feathering.
5. Extent to which age of the coffee affects its tendency to feather.
6. Procedure followed in mixing coffee and cream.

METHOD OF PROCEDURE

The degree of feathering was determined in coffee brew made from different water selected from the following group:

Water sample No.	Water used	Ave. pH
1	Tap	7.2
2	Distilled plus Mg. (10 ppm.) and Ca (30 ppm.)	6.95
3	Distilled plus Mg. (20 ppm.) and Ca (60 ppm.)	6.75
4	Distilled plus Mg. (30 ppm.) and Ca (80 ppm.)	6.70
5	Distilled plus Mg. (40 ppm.) and Ca (120 ppm.)	6.90

The coffee was measured with a measuring tablespoon and unless otherwise stated was used at the rate of one level tablespoon per measuring cup of water.

The regular procedure for making the coffee by the percolator method was to heat the coffee for five minutes after it began percolating. When made by the drip method the water was poured over the coffee in a regular coffee dripolator. When the coffee was boiled the percolating pot with the percolator removed was used.

The amount of feathering was determined using coffee brews at four different temperatures (120°, 145°, 170°, and 195° F.). One hundred ml. of coffee brew was poured into a 100 ml. glass graduate. When the temperature was properly adjusted 10 ml. of fresh 22% cream homogenized at 700 pounds pressure and at a temperature of 140° F. was added. The contents were mixed by pouring into a beaker and back into the graduate. The coagulum that rose to the top was then measured in terms of ml.

All pH measurements were made on the cold coffee brew, using a Coleman portable type apparatus with glass electrode.

The coffees were scored on the basis of the amount of coagulum formed during the feathering test. Although this method is to be criticized because of possible slight variations in the packing of the coagulum in the top of the graduate, the method is rapid and was thought to be sufficiently accurate to give relative values. Since the coffees made with water of varying calcium and magnesium content represented different degrees of severeness of the

test it was necessary to assign arbitrary values to these different coffees in order to arrive at a total score for each coffee made with the four different waters. The assumed values for each cubic centimeter of coagulum formed were as follows:

Temperature	Score value				
	Water 1	Water 2	Water 3	Water 4	Water 5
120° F.	*	*	*	*	*
145° F.	*	*	*	6	4
170° F.	*	*	5	3.5	2
195° F.	*	5	3	2	1

* No value was assigned as feathering did not occur when using this water at the indicated temperature.

RELATIVE FEATHERING TENDENCIES OF COFFEES OF DIFFERENT BRANDS

To compare the relative feathering tendencies of coffees, samples of 26 different brands were used. The coffee brews were made by the percolator method. The results are given in Table 1.

Examination of the data in Table 1 will show some of the coffee brews to differ in their feathering tendencies. It was only when a water containing magnesium and calcium, added to the extent of 40 and 60 parts per million respectively, was used, that the brand of coffee became a factor. It may be concluded, therefore, that it would be only when unfavorable conditions existed that this tendency on the part of certain coffee to be a factor, would be of any significance. For example, when the cream was of high quality, contained a normal salt balance, and was not processed in such a way as to produce excessive fat clumping, and when the water used to make the coffee was not high in calcium or magnesium content, tendencies for certain brands of coffee to favor feathering more than other brands would be of no particular importance. However, there may be cases where the cream is so nearly destabilized when mixed with the hot coffee that the particular ingredient in the coffee responsible for the feathering may be just the factor necessary to bring about the coagulation. This condition may account for slight variations in results obtained by different dispensers of coffee brew that are being served by the same dairy.

Just what the coffee constituent is that favors cream feathering is not known. Whitaker (4) suggests the ash content of the bean as important in this respect. Acetic, formic and valeric acids have been reported by various investigators (5) of the composition of the volatile oils of coffee suggesting coffee acidity as a possible factor in feathering. While no exact correlation seems to exist between pH of the brew and feathering there are some general tendencies in this respect as shown by the data in Table 2. The lack of a clear cut correlation between the pH of the brew and feathering would indicate the presence of more than one constituent in the coffee that is rel to the heat coagulation of the cream protein.

3. Significance of amount of coffee used.
4. Relation of coffee species, degree of roast and method of curing to feathering.
5. Extent to which age of the coffee affects its tendency to feather.
6. Procedure followed in mixing coffee and cream.

METHOD OF PROCEDURE

The degree of feathering was determined in coffee brew made from different water selected from the following group:

Water sample No.	Water used	Ave. pH
1	Tap	7.2
2	Distilled plus Mg. (10 ppm.) and Ca (30 ppm.)	6.95
3	Distilled plus Mg. (20 ppm.) and Ca (60 ppm.)	6.75
4	Distilled plus Mg. (30 ppm.) and Ca (80 ppm.)	6.70
5	Distilled plus Mg. (40 ppm.) and Ca (120 ppm.)	6.90

The coffee was measured with a measuring tablespoon and unless otherwise stated was used at the rate of one level tablespoon per measuring cup of water.

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Temperature	Score value				
	Water 1	Water 2	Water 3	Water 4	Water 5
120° F.	*	*	*	*	*
145° F.	*	*	*	6	4
170° F.	*	*	5	3.5	2
195° F.	*	5	3	2	1

* No value was assigned as feathering did not occur when using this water at the indicated temperature.

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TABLE 1

Comparison of different coffees in their tendencies to produce feathering

Brand No.	pH	Brew 1 ml curd formed			pH	Brew 2 ml curd formed			pH	Brew 3 ml curd formed			pH	Brew 5 ml curd formed			Score*
		145°	170°	195°		145°	170°	195°		145°	170°	195°		145°	170°	195°	
1	6.35	0	0	0	4.90	0	0	0	4.80	0	0	12	4.70	1.5	13.5	17	86
2	6.70	0	0	0	4.82	0	0	0	4.90	0	0	0	4.78	0	0	15	15
3	6.45	0	0	0	4.92	0	0	0	4.91	0	0	0	4.80	0	11	13.5	35.5
4	6.68	0	0	0	4.75	0	0	6	4.67	0	0	10.5	4.58	7.5	14	16	135.5
5	6.87	0	0	0	4.70	0	0	0	4.65	0	0	8	4.51	9	12.5	13.5	98.5
6	7.18	0	0	0	4.70	0	0	0	4.70	0	0	1	4.63	0	7	12	29
7	6.80	0	0	0	5.05	0	0	0	4.95	0	0	0.5	4.90	0	0	14	15.5
8	7.15	0	0	0	4.95	0	0	0	4.90	0	0	9	4.88	0	6	16	55
9	6.90	0	0	0	5.00	0	0	0	4.98	0	0	0	4.82	0	7	13.5	27.5
10	6.95	0	0	0	5.08	0	0	0	5.02	0	0	0	4.92	0	5	11.5	21.5
11	7.05	0	0	0	5.01	0	0	0	5.00	0	0	0	4.95	0	9.5	10	29
12	7.60	0	0	0	5.20	0	0	0	5.19	0	0	0	5.05	0	0	10	10
13	7.35	0	0	0	5.02	0	0	0	5.02	0	0	4	4.88	4	10	15	63
14	7.68	0	0	0	5.09	0	0	0	5.08	0	0	10	4.99	0	7	15	59
15	7.42	0	0	0	5.29	0	0	0	5.23	0	0	0	5.15	0	0	11	11
16	7.39	0	0	0	5.46	0	0	0	5.37	0	0	0	5.26	0	0	4	4
17	7.27	0	0	0	5.10	0	0	0	4.90	0	0	1	4.91	0	4	13	24
18	6.68	0	0	0	5.09	0	0	0	5.06	0	0	2	4.88	0	12	13	23
19	7.02	0	0	0	5.17	0	0	0	5.08	0	0	0	5.02	0	13	12	18
20	7.30	0	0	0	5.12	0	0	0	5.07	0	0	0	4.97	0	18	12	28
21	7.24	0	0	0	5.02	0	0	0	4.93	0	0	3	4.82	2	12	17	58
22	7.01	0	0	0	5.24	0	0	0	5.26	0	0	2	5.10	0	1	12	20
23	7.05	0	0	0	5.20	0	0	0	5.10	0	0	1	5.02	1	7.5	12.5	34.5
24	7.02	0	0	0	5.16	0	0	0	5.18	0	0	5	5.03	0	9	12	45
25	6.37	0	0	0	4.82	0	0	1	4.80	0	6	8	4.70	5	11	13	114
26	6.65	0	0	0	5.16	0	0	0	5.10	0	0	0	......	0	11	......	......

* The higher the score the greater the degree of feathering.

TABLE 2

Relation of pH of coffee brew to cream feathering

Coffee No.	pH* Score**	
	Group 1	
16	5.36 – 4	Score 0–24 Ave. pH 5.08
12	5.15 – 10	
15	5.22 – 11	
2	4.83 – 15	
7	4.97 – 15.5	
19	5.09 – 18	
10	5.01 – 21.5	
22	5.20 – 22	
18	5.01 – 23	
17	4.97 – 24	
	Group 2	
9	4.93 – 27.5	Score 25–49 Ave. pH 4.97
20	5.05 – 28	
6	4.68 – 29	
11	4.99 – 29	
23	5.14 – 34.5	
3	4.88 – 35.5	
24	5.12 – 45	
	Group 3	
8	4.91 – 55	Score 50–74 Ave. pH 4.96
21	4.92 – 58	
14	5.05 – 59	
13	4.97 – 63	
	Group 4	
1	4.80 – 86	Score 75–150 Ave. pH 4.71
5	4.62 – 98.5	
25	4.77 – 114	
4	4.67 – 135.5	

* Based on average of brews 2, 3 and 5.
** Represents total score for groups 2, 3 and 5.

ORIGIN OF COFFEE AND METHOD OF ROASTING BEAN AS RELATED TO FEATHERING

There are two general methods (6) of curing coffee after the ripe pods or cherries have been picked from the trees. In countries such as Brazil which have a dry period during the harvest season they spread the ripe cherries out on drying floors to dry in the sun until the flesh which surrounds the coffee beans becomes a dry, shriveled shuck. The beans are then threshed free of the brittle shucks and after being screened for size and hand picked to remove imperfections are ready for market. This is known as the dry method of curing, as opposed to the wet method used in damper climate like that of Colombia.

In the wet method of curing the freshly picked cherries are first put through a machine which removes the greater part of the flesh. They are then placed in cistern-like reservoirs full of water where the [illegible] flesh is removed by controlled fermentation. This fermentation not only [illegible]eaks

down the remaining flesh but also loosens a parchment-like skin that surrounds the beans. The beans are then artificially dried and screened.

The curing of the coffee has considerable influence upon the flavor characteristics of the bean. Brazil produces approximately two thirds of the world's supply of coffee, most of which is cured by the dry method, whereas Colombia, the next largest producer of coffee, due to its climatic conditions, uses the wet method.

Most of the better quality brands of coffee are for the most part blends of Santos and Colombian coffees. Bourbon Santos is a term used to describe the coffee which grows on the younger Santos type trees, a superior product to that grown on the older trees. Unwashed Salvador is a dry-cured coffee similar to the Bourbon Santos. The Maracaibo comes out of the port of Maracaibo, Venezuela.

Coffee is roasted to produce the desired flavor. Up to a certain optimum point the roasting eliminates the raw acrid taste of the green coffee and develops the true characteristic flavor.

To determine what relations there may be between the method of curing and the degree of roast of the bean to the feathering of cream, the tests recorded in Table 3 were made. The coffee was made by percolator method.

Although some differences were obtained in feathering tests using the different types of beans the data do not definitely indicate that the method of curing the bean has a relation to the occurrence of feathering. Unfortunately, it was not possible to secure samples of the same coffee cured by both the wet and dry methods. Such samples, if available, might make it possible to detect a minor difference that would not be evident otherwise.

In the case of the degree of roast, however, the data show rather clearly that the more roasting the bean is subjected to the less tendency there is for feathering to occur. The explanation for this effect is to be found in the higher pH value of the brews made from the beans receiving the most roasting.

TABLE 3

Effect of method of curing bean and degree of roast upon pH of brew and extent of feathering*

Bean	Light roast		Medium roast		Dark roast	
	Score	pH	Score	pH	Score	pH
Bourbon Santos	114.25	4.86	88.5	4.90	84.5	5.00
Colombian (Washed)	139.00	4.84	123	4.92	101	4.97
Unwashed Salvador	97.00	4.91	81	4.95	63	4.97
		Light medium roast		Medium dark roast		
		Score	pH	Score	pH	
Washed Maracaibo		73.5	4.97	18	5.09	
Natural Maracaibo		35	5.01	0	5.13	

* pH and score values represent the average values obtained with the coffee brews made with water Nos. 2, 4 and 5.

TABLE 4

Relation of amount of coffee used in brew to its tendency to feather

Coffee No.	Amount coffee	pH	Brew 3 ml. curd formed			pH	Brew 4 ml. curd formed			pH	Brew 5 ml. curd formed			Ave. pH
			145°	170°	195°		145°	170°	195°		145°	170°	195°	
12	1 tb.	5.04	0	0	0	4.99	0	0	11	4.92	0	6	16	4.98
	2 tb.	5.03	0	0	0	4.99	0	0	10	4.95	0	3	13	4.99
	3 tb.	5.07	0	0	0	5.03	0	0	10	5.00	0	2	10	5.03
15	1 tb.	5.02	0	0	4	5.00	0	2	11	4.91	1	12	14	4.98
	2 tb.	5.01	0	0	0	4.95	0	0	10	4.89	0	8	13	4.95
	3 tb.	4.98	0	0	3	4.94	0	3	10	4.91	0	10	13	4.94
6	1 tb.	4.91	0	0	7	4.78	0	8	15	4.79	3	11	15	4.83
	2 tb.	4.87	0	0	13	4.84	0	5	16	4.79	1	13	15	4.83
	3 tb.	4.89	0	0	14	4.81	0	8	16	4.80	1	13	17	4.83
9	1 tb.	4.81	0	0	4	4.79	0	2	11	4.72	0	4	14	4.77
	2 tb.	4.79	0	0	9	4.74	0	3	12	4.73	0	9	14	4.75
	3 tb.	4.82	0	0	6	4.79	0	8	12	4.77	0	8	14	4.79

METHOD OF MAKING THE COFFEE AS A FACTOR IN CREAM FEATHERING

Since methods of making coffee vary considerably with the ideas of the individual brewer, an attempt was made to determine to what extent such variations may be a factor in the cream feathering problem.

Amount of Coffee Used

The first variable studied was the amount of coffee used. Four coffees were used in this experiment, two that had been rated high from a feathering standpoint and two that had been rated rather low. The results of the feathering tests and the pH measurements of the brews are given in Table 4. It will be observed that there was no consistent variation in the effect of increasing the amount of coffee used in the brew upon the amount of curd formed, the tendency being towards uniformity in results. An explanation for these results is found in the pH measurements which show but slight differences in the brews containing varying amounts of coffee. Coffee brew undoubtedly contains a buffer substance in addition to the acid constituents which are present in more or less definite proportions regardless of the amount of coffee used.

Method of Preparing Brew

Coffee brews made from seven different coffees by three different methods —boil, percolator and dripolator—were compared for cream feathering tendencies, using water number 5. It will be noted from the data in Tables 5 and 7 that both pH and the extent of feathering varies but little with the method of preparing the brew although there is some indication that coffee made by the dripolator method will have a slightly lower pH and slightly greater feathering tendencies than that made by either the boil or percolator methods. Such differences may be attributed to variations in the extent to which certain volatile acids such as acetic are retained by the brew.

Age of Coffee as a Factor

If we are to believe the advertising propaganda of the coffee industry, coffees undergo certain chemical changes during storage that materially affect their quality. Though most investigations attribute the age deterioration of coffee to oxidation of the fatty constituents, Prescott (5) *et al.* are of the opinion that furfuryl alcohol plays an important part in the staleness of coffee. To determine to what extent age of the coffee may be a factor in cream feathering samples of varying age were secured from five different companies. It will be noted from the data in Table 6 that without exception the brews made from the older coffees had a lower pH and as would be expected the general tendency was for a greater feathering from these brews. It is also interesting to note that the coffee substitute responded in the same way as the coffees as far as pH and feathering were concerned. These data

TABLE 5

Relation of method of making coffee to degree of cream feathering
(Water No. 5 used)

Coffee Brand No.	pH	*Boil* ml. curd formed			Score	pH	*Percolator* ml. curd formed			Score	pH	*Dripolator* ml. curd formed			Score
		195°	170°	145°			195°	170°	145°			195°	170°	145°	
4	4.72	15	9	4	49	4.70	15	9	5	53	4.72	15	10	9	68
11	4.90	12	6	0	24	4.90	8	9	0	26	4.87	14	7	0	28
10	4.95	12	10	0	32	4.91	9	7.5	0	24	4.89	13	9	0	31
10a	4.91	13.5	11	0	35.5	4.91	13	8.5	0	30	4.85	12	10	3	44
10b	4.85	13	12	3	49	4.82	14	11	5	56	4.85	16	6	5	48
10c	4.92	13	10	0	33	4.90	13	8	0	29	4.90	10	10	0	30
10d	4.94	13	0	0	13	4.95	7	2	0	11	4.97	13	0	0	13
Ave.	4.88				33.6	4.87				32.7	4.86				37.4

TABLE 6

Effect of age of coffee upon pH of brew and its tendency to cause feathering

Coffee No.	pH		ml. of feathering						Score
			195° F.		170° F.		145° F.		
	Brew 3	Brew 5	Brew 3	Brew 5	Brew 3	Brew 5	Brew 3	Brew 5	
4									
a. Fresh	4.80	4.76	14	16	10	13	0	8	166
b. 2 years old	4.75	4.69	14	15	5	10	0	10	142
Coffee substitute									
a. Fresh	4.85	4.84	5	16	1	12	0	0	60
b. One year old	4.83	4.80	12	16	3	15	0	0	97
10									
a. Fresh	5.00	4.91	0	9	0	7.5	0	0	24
b. 5 months old	4.87	4.80	7	14	6	9	0	0	83
11									
a. Fresh	4.95	4.90	6	8	0	9	0	0	44
b. 5 months old	4.85	4.78	8	15	2	11.5	0	4	88
1									
a. Fresh	4.80	4.78	13	15	0	11	0	0	76
b. 6 months old	4.79	4.77	9	15	3	11	0	3	91
c. 4 years old	4.73	4.70	14	15	7	11	0	6	138

TABLE 7

Comparison of the degree of feathering when adding cream to coffee or coffee to cream (Water V used)

Coffee number	pH	Cream to coffee ml curd formed			Score	Coffee to cream ml curd formed			Score
		195° F.	170° F.	145° F.		195° F.	170° F.	145° F.	
A—Percolator method									
4	4.70	15	9	5	53	15	12	12.5	88
11	4.90	8	9	0	26	9.5	12	0	33.5
10	4.91	9	7.5	0	24	9	10	0	29.0
a	4.91	13	8.5	0	30	13	9	0	31
b	4.82	14	11	5	56	12	11	3	46
c	4.90	13	8	0	29	13	9	0	31
d	4.95	7	2	0	11	6	5	0	16
Ave.					32.7				39.2
B—Boil method									
4	4.72	15	9	4	49	14	12	10	78
11	4.90	12	6	0	24	13	9	0	31
10	4.95	12	10	0	32	13	7	0	27
a	4.91	13.5	11	0	35.5	13	12	0	37
b	4.85	13	12	3	49	14	12	10	38
c	4.92	13	10	0	33	13	11	0	35
d	4.94	13	0	0	13	12	4	0	20
Ave.					33.6				38
C—Dripolator									
4	4.72	15	10	9	68	14	14	11	86
11	4.87	14	7	0	28	12	14	6	64
10	4.89	13	9	0	31	12	7	0	26
a	4.85	12	10	3	44	13.5	6	0	25.5
b	4.85	16	6	5	48	15.5	11	8	48
c	4.90	10	10	0	30	16	13	0	42
d	4.97	13	0	0	13	12	4	0	20
Ave.					37.4				44.4

indicate that certain chemical changes likely occur during the storage of the coffee that accentuates the beans' effect upon cream feathering. No attempt was made to determine the nature of this change.

Method of Combining Cream with the Coffee Brew

The usual procedure in hotel and restaurant service is to add the cream to the coffee, although in some cases the reverse is true. That the former method might be expected to produce somewhat less feathering is indicated by the data in Table 7. Although the differences were not great a distinct trend will be noted toward greater feathering when the hot coffee was added to the cream. That the significant factor is the rapidity with which the coffee and cream mix when combined is illustrated by the fact that creams which ordinarily do not feather may be made to do so by slowly adding the cream to the coffee so that it more or less floats on the surface. This is particularly true when the quantity of cream added is less than ordinary.

CONCLUSIONS

In comparing the feathering tendencies of the brew made from 26 different brands of coffee the following conclusions are drawn:

1. Some coffees are more likely to cause feathering than others. This difference is likely due to variations in the pH of the brews resulting from variations in the soluble acids present in the beans.
2. It could not be shown that the method of curing the beans has any relation to the pH of the brew and feathering.
3. The degree of roast to which the bean is subjected affects feathering. The more roasting the bean is subjected to the higher the pH of the brew and the less the degree of feathering.
4. The concentration of the coffee in the brew has no definite relation to feathering.
5. The method of brewing, i.e., boil, percolator or dripolator, is not of great importance although slightly more feathering was obtained with brews made by the dripolator method.
6. The brew made from aged coffee has a lower pH and is more likely to produce feathering than that made from fresh stock.
7. More feathering may result when the coffee is added to the cream than when the cream is added to the coffee. Rapidity of mixing is thought to be the limiting factor.

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(5) PRESCOTT, S. C., EMERSON. R. L.,-PEEKES, L. V., JR. The staling of coffee. Food Research, 2: No. 1, pp. 1–20.

(6) Correspondence of Mr. S. M. Gastren of the Kellogg Company, Battle Creek, Michigan, with the senior author.

THE THIRTY-THIRD ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

R. B. STOLTZ
Secretary-Treasurer

The American Dairy Science Association was called to order by the President, H. W. Gregory, in Campbell Hall on the campus of the Ohio State University on Tuesday morning, June 14, 1938, at 10:30 A. M., for the thirty-third annual meeting.

The program printed in the May issue of the Journal of Dairy Science was arranged by a program committee headed by Dr. T. S. Sutton. The May issue of the Journal also contained the abstracts of the various papers presented.

Vice-President Lewis L. Morrill, Ohio State University, gave an address of welcome. President H. W. Gregory gave the following response:

PRESIDENT'S ADDRESS

"Today our Association meets for the thirty-third annual meeting and it is interesting to note that we have among our membership a number of men, who laid the early foundation for the American Dairy Science Association, still taking a very active part in the Association.

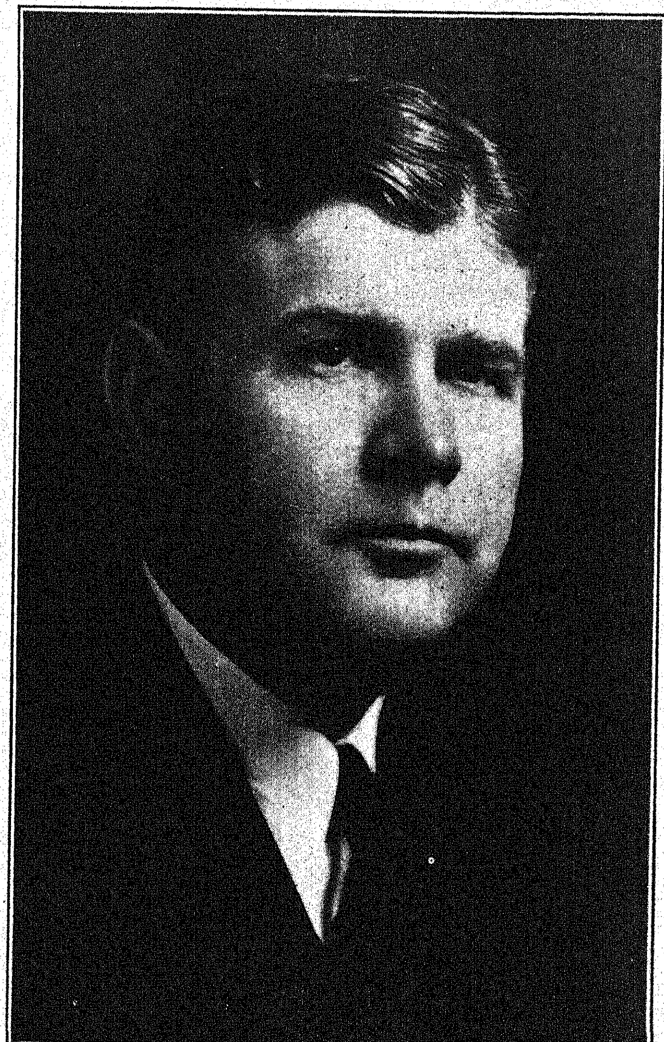
In 1906, when the American Dairy Science Association was first started under the name of "The Official Dairy Instructors' Association," our problems were somewhat different from those we have before us today. The name of our Association in the beginning was very descriptive of one of our early problems which was "what to teach and how to teach it." If we read available dairy reports, catalogue descriptions of courses offered in dairying, note equipment used in our dairy laboratories in our agricultural colleges at the time our Association started, and compare the dairy curricula and facilities for research at the present time in our schools, we realize the development that has taken place during this comparatively short period in the dairy industry. This Association has played a very important part in bringing about these changes. Our industry has been and is being revolutionized by science. We who are connected with the dairy industry are constantly called upon to readjust our thinking and methods of teaching as progress is made in dairy research. Due largely to many new developments in our industry and improved methods of teaching, a number of our members have expressed an interest in having a committee of this Association study the dairy curricula offered in our different institutions. A rather comprehensive committee was appointed rather late in the year for this purpose and a complete report cannot be expected this year, but with the enthusiasm and interest of Dr. H. B.

Ellenberger, general chairman of this committee, I am sure we can look forward to a later report which will be of considerable interest to a large number of our members.

Our organization has always given a great deal of attention to problems relating to inspection, sanitation, standardization of equipment, methods and products. In 1911, as a result of the activities of a committee from this Association, the first draft of standardizing testing glassware was made, and later a number of states passed what is generally called a milk and cream testers' license law, requiring the use of standardized glassware. A resolution made by the committee on sanitary procedure of the International Association of Milk Dealers was sent to this Association during the year, calling attention to the need of cooperation in problems having to do with sanitation. This resolution recommended that a program be undertaken cooperatively to determine good industry practices by survey and by original research by national dairy organizations interested. Mr. Ernest Kelly, Assistant Chief of the Bureau of Dairy Industry, United States Department of Agriculture, was appointed chairman of the committee to represent the American Dairy Science Association on this important project.

During the early history of our Association we gave considerable attention to dairy laws, rules, and regulations, especially those enforced by our state and city governments. Due to improvement in our methods of production, processing and improvement in transportation facilities for milk and cream, a large amount of these products today enters into interstate commerce. Many of the states have milk and cream testers' license laws, state cream grading laws, and state laws relating to methods and equipment used in production. There is very little uniformity in the different state dairy laws and if there were the enforcement in the different states would not likely be uniform. Dut to this increased interstate traffic of milk and cream, are we not in need of a federal law which would give some federal agency jurisdiction in such shipments of milk and cream regarding the weighing, testing, and grading, especially when cream or milk originates in a state which enforces such state laws? A federal agency having jurisdiction over interstate shipments would tend to bring about uniformity of state dairy laws, would be a great aid to states now enforcing testing, grading and sanitary laws, and would be an encouragement to the dairy industry in those states that do not have such laws to propose similar laws to their legislatures.

As our Association increases in membership and importance the demand for the American Dairy Science Association to approve or condemn certain proceedings, methods or statements is increasing, and while the policy of this Association has been very conservative along this line, there has not been any definite procedure to follow in securing approval of this



EARL WEAVER, President

Association for such requests. Last year a committee was appointed at our annual meeting to give this consideration and suggest a procedure to be followed when such requests are submitted to the Association or any section of the Association. This committee has made its report which will be considered by the directors, and I hope that from this report the Association will be able to adopt a definite policy in handling such requests in the future.

There has been considerable interest among the membership in forming junior chapters of the American Dairy Science Association. Prof. J. A. Nelson, member of the Board of Directors, has attempted to make a survey this year to find out how general is the demand for such an organization, and also to determine what degree of success similar organizations have had in forming such chapters. If the Board of Directors thinks that there is enough interest in junior or local chapters of the Association, after considering Professor Nelson's report, recommendation for adopting such a procedure will be made to the Association.

Last February I received a letter from Dr. A. C. Dahlberg, editor of our Journal, stating that he did not wish to be reappointed as editor of the JOURNAL OF DAIRY SCIENCE. During the ten years Doctor Dahlberg has been editor our Journal has continued to increase in importance and recognition in the scientific field. Research articles in the Journal have increased over 50 per cent. The Journal was changed from six to twelve issues yearly. Abstracts of literature on dairy cattle and literature reviewing articles on timely, selected topics are only a few of the many services added to the Journal in the last few years. No one thing indicates the sound basis on which the Journal has been built better than the fact that all these services have been added without increasing the annual dues. These extra services have demanded more and more time of the editor in reading manuscripts, galley proofs, indexing of articles, and increased correspondence until it is nearly impossible to handle the Journal incidental to one's work. Doctor Dahlberg stated that it is with a real sense of personal loss and regret that he asked to be relieved of the position of editor.

A meeting of the Journal Management Committee, Doctor Dahlberg and myself, was held in Chicago, March 5, 1938, at which time the position of editor for the Journal was gone over very thoroughly with Doctor Dahlberg with the hope that some arrangement might be made so that he would continue as editor. Upon the insistance of Doctor Dahlberg, that his resignation be accepted and a new editor be secured, the Journal Management Committee was asked to give consideration to the securing of an editor for the JOURNAL OF DAIRY SCIENCE and to make recommendations in time to submit to the Board of Directors at the annual meeting in June.

Doctor Dahlberg has been a very capable editor. He has spared neither time nor effort to make the Journal a success, and our Association greatly appreciates the splendid services he has rendered the Association as editor and regrets that he considers it necessary to resign at this time.

Our Association has been growing rapidly and a great deal of time in the last few years has been given to improving our organization and getting it on a good operating basis. There is no better evidence of the success of our efforts in this direction than the secretary-treasurer's report for the year ending December 31, 1937, which shows our total assets now amount to a little over $17,000, $9,000 of which is invested in government bonds. The public accountant, who was secured to audit our books for 1937, makes the following statement in his report: "The comparative profit and loss statement reveals the changes in this year's business as compared to the two previous years. The income of 1937 exceeded the income of 1935 by $4,610.38. Although the increase over 1936 was only $1,305.28, it is interesting to note that there was a switch from associate subscribers to members and subscribers. Advertising increased $992.93, while operating expenses for the period increased only $296.78. These results indicate that the Association is arriving at the point of economical operation when the profits were increased $1,305.38 over the previous year with an increase in expense of only 22.7 per cent."

Our secretary-treasurer, Prof. R. B. Stoltz, deserves a great deal of credit for the interest, time and effort he has devoted to the American Dairy Science Association and the business management of our Journal. At the present time we have 1037 members and 825 subscribers, and our secretary hopes that by the end of the year the number receiving the Journal will increase to at least 2000. To keep our Journal on a sound financial basis and make the improvements that are desired, membership and subscriptions are very necessary. Due to the fact that our membership is widely scattered, the maintaining or increasing of our membership in this association must be done largely by individual members accepting some responsibility in securing members or subscribers. In January, this year, a representative in each state where we have members or subscribers was appointed with the hope that these representatives would make a special effort to see that those who are eligible would have an opportunity to subscribe to our Journal. Due to the rapid development and changes in our industry, there are a number of problems which many of our members believe should have the attention of our Association, but because of lack of time, finances, etc., we have not been able to give all these problems the consideration they deserve.

At this time I wish to express my personal appreciation to the numerous individuals, committees and officers of this Association for their assistance and cooperation during the year, and, especially, I wish to

commend Dr. T. S. Sutton and his committee for getting together our annual program in time to have it published and in the hands of our members several weeks before the annual meeting. This policy followed by our program committee has already added a great deal to our meeting and evidence of the value of such a procedure will undoubtedly be more in evidence before our meeting closes.

GUEST SPEAKER

Dr. K. Hickman, of the Eastman Kodak Company, Rochester, New York, was then introduced and gave a most interesting and instructive talk on "Vacuum Extraction of Accessory Food Factors."

ATTENDANCE

According to J. H. Erb, who had charge of the registration, the attendance showed that there were 620 registered, which is the largest registration at any of our annual meetings. Thirty-nine states, the District of Columbia, Canada and two foreign countries were represented. There were 358 members, 89 non-members, 125 ladies and 48 children registered.

S. M. Salisbury, chairman of the committee to submit new by-laws, presented mimeographed copies of the by-laws to each person present, and it was announced that these by-laws would be discussed and voted upon at the business session Thursday at 3:30.

After lunch the program as outlined was followed.

Tuesday evening the President of the University and the Dean of the College of Agriculture gave a reception for the Association at the Faculty Club.

Wednesday, June 15, the papers were read as provided for in the program. The men were given a complimentary barbecue lunch in the judging pavilion. In the evening the visitors were entertained in University Hall by a "rube" band and colored movie films of a trip around the world. They then were entertained in the natatorium by a diving and swimming exhibition. Following the evening entertainment a social time was then had between the natatorium and gymnasium.

On Thursday, June 16, papers were read and the business session was provided for as in the program. Thursday evening the annual banquet was given at the Neil House.

The ladies and children were entertained as provided for in the program published in the May Journal.

GENERAL BUSINESS MEETING

American Dairy Science Association

Columbus, Ohio, June 16, 1938

President Gregory called the meeting to order at 3:30 P. M., in the auditorium of Campbell Hall, Ohio State University, on Thursday, June 16, 1938. One hundred twenty-seven members were present.

The secretary-treasurer read the financial report which had previously been approved by the Board of Directors. Upon motion duly seconded the report was accepted and referred to the Auditing Committee.

Herbert Otting, chairman of the Auditing Committee, then gave the following report:

Columbus, Ohio
April 13, 1938

To the Members of the
American Dairy Science Assn.:
Gentlemen:

The Auditing Committee of the American Dairy Science Association has made an examination of the books and statements of the Secretary-Treasurer as of December 31, 1937.

It is our opinion, based upon such examination, that the books have been kept accurately and that the balance sheet and related summary of profit and loss fairly present the financial condition of the American Dairy Science Association.

Respectfully submitted,
T. S. Sutton
W. L. Slatter
H. E. Otting, *Chairman*

CIRCULATION OF JOURNAL

The Secretary then submitted a map of the United States showing the circulation of the Journal in each state and the allotted number which was obtained by dividing the population for each by 50,000 persons. The District of Columbia had the highest circulation, and Vermont was the highest state having a circulation of 21 and an allotment of 7. The states leading in total circulation are as follows: Ohio, 157; New York, 154; Illinois, 114; Pennsylvania, 94; California, 90; Massachusetts and Wisconsin, 56; Minnesota, 50; Michigan and District of Columbia, 49. At the present time the total circulation is 1898 of which 1073 are members, 704 subscribers and 121 associate subscribers. At the annual meeting a year ago the total circulation was 1741, or 157 less than today.

Thus far this year we have obtained 215 new members. These new members are from the following states: Ohio, 65; New York, 15; Pennsylvania, 14; Massachusetts, 12; Maryland, 10; California, 9; Michigan and Indiana, 8; Vermont, 6; Washington, Utah and Illinois, 5; Canada, Wis-

consin, New Jersey, Minnesota, Iowa, Dist. of Columbia and Connecticut, 4; Missouri and Tennessee, 3; and 19 scattered.

The problem of membership is that we have such a large number of members that lapse each year. If the students graduating from the various dairy schools were educated to the idea that in order to keep up with the times and prevent themselves from falling in a rut, it is essential that they affiliate themselves with this Association, you would be doing your students a great favor and the problem of recruiting new members would be solved.

REPRINTS FOR BULLETINS

Many experiment stations and colleges are now using reprints from the JOURNAL OF DAIRY SCIENCE instead of having technical bulletins printed. It is much less expensive for you to buy reprints from the JOURNAL OF DAIRY SCIENCE after having had an article accepted, than it is to print your own bulletins.

MORE ACTIVITY IN THE PRODUCTION FIELD

The Association is now printing abstracts in the field of dairy production. An effort should be made to obtain advertising from the breed associations, from companies manufacturing dairy feeds and other equipment for dairy cows. An effort should also be made to increase our membership among commercial men in the field of production.

Early this year the wife of a college graduate presented her husband with a membership in the Association for his wedding anniversary gift. With such a helpmate, he will not be permitted to fall in the rut.

PRODUCTION SECTION

Mr. W. E. Krauss, chairman of the Production Section, read the following report:

The Production section held five sessions at the regularly scheduled hours and places with the Section chairman, W. E. Krauss in the chair for the Symposium on Nutrition; H. W. Cave, chairman for the pasture, hay and silage session; W. E. Krauss, chairman for the vitamin and mineral session, the milk secretion, metabolism and udder disease session; and J. B. Fitch, chairman for the final session on Thursday afternoon.

All sessions were very well attended, at times almost taxing the seating capacity of 200 in Room 100 of the Botany and Zoology Building, where the sessions were held. The papers presented were without exception well prepared, well presented and in most cases accompanied by slides, mimeographed charts and tables, or other illustrated material. The availability of the printed abstracts in the hands of the members was commented upon by many as being a material help in following the presentation of the wide range of subjects reported upon.

All but two of the papers listed on the printed program were presented. The marked program attached indicates the author making the actual presentation.

The business meeting of the Production Section was called at 4:15 on Wednesday afternoon. The minutes of the 1937 meeting at Lincoln, Nebraska, were read and approved.

Reports were submitted by the various standing committees and approved at the time, or in a short additional business meeting held at 11:30 on Thursday morning. Copies of these reports are attached.

Points of particular interest incorporated in the reports follow:

Breeds Relations Committee, C. N. Shepardson, chairman.

1. The cow year method of calculating herd averages was approved.
2. The feeding or injection of thyroxine to cows on official test was considered an undesirable and unacceptable practice.
3. It was suggested that no changes be made in the uniform herd test blank.

Committee on Rules for Conduct of the Students National Dairy Cattle Judging Contest, I. W. Rupel, chairman.

It was recommended:

1. To use numbers instead of letters in designating animals.
2. To change the score card for grading oral reasons (copy attached).

Committee on Awards for the Students National Judging Contest, A. A. Borland, chairman.

It was recommended:

To attempt to increase the number of scholarships available for winners in the Students National Judging Contest.

Committee on Methods of Measuring Results of Pasture Investigations, R. N. Lush, chairman (presented by G. Bohstedt).

Two items were emphasized:

1. Conditions for collecting samples, especially for mineral analysis, were enumerated.
2. A study of the size and number of clip plots is to receive continued attention.

Committee on Standard Methods, A. E. Perkins, chairman.

It was recommended:

That the committee be increased to include a specialist in the following fields:

a. Milk analysis
b. Blood and urine analysis
c. Feeds and feces
d. Endocrines
e. Vitamins
f. Enzymes

The chairman of the Production Section will appoint additional members to this committee after due consideration.

All standing committees were reappointed with their present personnel except for the Breeds Relations Committee. E. E. Heizer and W. L. Crandall were appointed for a period of three years to replace C. N. Shepardson and E. N. Schultz whose terms expired. H. A. Herman was appointed for a period of two years to replace Earl Weaver who resigned.

A. C. Ragsdale, chairman of the Nominating Committee, presented names for the offices of vice-chairman and secretary for 1939. A. H. Kuhlman of Oklahoma was elected vice-chairman, and A. L. Beam of Pennsylvania was elected Secretary. H. W. Cave of Kansas, vice-chairman for this year, automatically becomes chairman for 1939.

Respectfully submitted,

W. E. KRAUSS, *Chairman*

I. R. JONES, *Secretary.*

Upon motion duly seconded the report was accepted.

EXTENSION SECTION

E. N. Shultz, chairman of the Extension Section, submitted the following report:

The proceedings of the annual meeting of the Extension Section of the American Dairy Science Association were held June 14, 15 and 16, 1938, in the Horticulture Building of the Ohio State University at Columbus, Ohio, with Earl N. Shultz, chairman of the Section, presiding.

The program was organized and conducted under the direction of a program committee consisting of C. L. Blackman, Ohio State University; R. G. Connelly, Virginia Polytechnic Institute, and S. J. Brownell, Cornell University.

Twenty papers were presented and discussed during the sessions with an average attendance of eighty-six people. An instructive exhibition of extension educational methods and results was organized and presented by the Exhibits Committee composed of E. C. Scheidenhelm, Michigan State College; A. J. Cramer, University of Wisconsin; Floyd Arnold, Iowa State College; Leland Lamb, Cornell University. The states that furnished exhibits were: Massachusetts, New York, Connecticut, Virginia, Tennessee, National Dairy Council, Michigan, Vermont, Wisconsin, Kansas and Iowa. The field application of each exhibit was discussed before an audience of forty-five extension dairymen and others.

The general program committee was ably assisted by collaborating committees on Extension Exhibits, Dairy Cattle Breeding, Dairy Cattle Feeding, Production Testing, 4-H Dairy Clubs, Dairy Quality Improvement, Resolutions and Nominations. The chairmen of the committees presided for the presentation of their respective committee papers. The per-

sonnel of the committees, the title of papers and subjects and the schedules followed are indicated in the official American Dairy Science Association program.

The annual business meeting of the Extension Section was held Wednesday, June 15, 1938, at 4:00 P. M., in the Ohio State University Horticulture Building. At this meeting the following resolutions were adopted.

1. Whereas the officers and the Extension Section Program Committee, C. L. Blackman, Ohio State University; R. G. Connelly, Virginia Polytechnic Institute, and S. J. Brownell, Cornell University, contributed much time and thought to planning and developing this year's program, and as a result of their efforts a constructive program was evolved; therefore, be it resolved that we commend these officers and the program committee, and also the chairmen and members of the collaborating committees, for their fine accomplishments, and thank those who prepared papers and furnished exhibits. Furthermore, be it resolved that the extension exhibits be continued next year with a wider participation by the States.

2. The members of the Extension Section wish to thank the members of the faculty of the Animal Husbandry, the Dairy Production, and Dairy Technology Departments of the Ohio State University for the fine facilities placed at our disposal and the many courtesies extended to us, both of which have helped to make our meetings successful and enjoyable; therefore, be it resolved that a copy of this resolution be sent to Professors C. W. Gay, R. B. Stoltz and S. M. Salisbury and the Ohio Agricultural Experiment Station.

3. Whereas uniform rules and regulations for conducting Dairy Herd Improvement Associations were adopted by the Extension Section of the American Dairy Science Association one year ago and published and widely distributed by the United States Bureau of Dairy Industry, and whereas these regulations have been adopted in the main by most of the States; and whereas this Committee believes that the complete adoption of such rules would strengthen confidence in the Dairy Herd Improvement Association work throughout the country; therefore, be it resolved that the Extension Section urge all the States to put these regulations into effect.

4. Whereas the identification and permanent herd record program is now well underway with satisfactory results, and whereas the system was evolved after much effort, discussion and trial; therefore, be it resolved that we express our appreciation to the Bureau of Dairy Industry in general and to Dr. J. F. Kendrick, Chief, Division of Dairy Herd Improvement Association Investigations, in particular for the prompt and complete manner in which the records have been returned to the States.

A new secretary is elected for the Section each year and the other

officers are promoted, with the retirement of the incumbent president. O. J. Hill, Washington State College, was elected secretary, R. G. Connelly, Virginia Polytechnic Institute, succeeded to the office of vice-chairman and S. J. Brownell, Cornell University, became chairman of the Extension Section for 1939.

EARL N. SHULTZ
R. G. CONNELLY, *Secretary*

MANUFACTURING SECTION

B. E. Horrall, secretary of the Manufacturing Section, submitted the following report:

The Manufacturing Section held its meetings at the place and time indicated in the official program. All of the papers listed were presented with the exception of M-28, M-31 and M-37. The papers were very instructive and all of the sessions were well attended.

A motion was made to elect a vice-chairman in addition to a chairman and secretary this year. For succeeding years only a vice-chairman, who would automatically become chairman the forthcoming year, and a secretary would be elected. The motion was seconded and carried.

Reports were heard from the following committees:

1. Chemical Methods for the Analysis of Milk and Dairy Products
2. Quality Program for Dairy Products
3. Judging Dairy Products
4. Methods of Determining the Curd Tension of Milk
5. Score Cards for Sanitary Inspection of Dairy Farms and Milk Plants
6. Methods for Measuring the Oxidation of Milk Fat
7. Methods for the Bacteriological Analysis of Milk and Dairy Products. A financial report was also given for the sale of Bacteriological reports.

P. A. Downs of Nebraska was elected chairman; F. H. Herzer of Mississippi, vice-chairman; and J. I. Keith of Oklahoma, secretary, for the forthcoming year.

C. J. BABCOCK, *Chairman*
B. E. HORRALL, *Secretary*

COMMITTEE REPORTS

T. S. Sutton, chairman of the Program Committee, submitted the report for the committee as read in the minutes of the Board of Directors. Upon motion duly seconded the report was adopted.

In the absence of S. M. Salisbury, the by-laws, as read in the minutes of the Board of Directors, were presented by Secretary Stoltz, and upon motion duly seconded they were adopted.

PROPOSED BY-LAWS OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

ARTICLE I—MEMBERSHIP

Section 1. Any person is eligible to membership who is formally announced by an Agricultural College or Experiment Station, or by the Bureau of Dairy Industry of the United States Department of Agriculture or by the Canadian Department of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry, or any person filling a position of responsibility connected with the dairy industry who has had a college or university training in technical science, or any person filling a responsible position in the dairy industry of a professional character requiring a technical knowledge of dairying of a high order.

Section 2. Nominations for membership shall be submitted to the Secretary-Treasurer in writing signed by the applicant and endorsed by at least one member. In case of uncertainty regarding the eligibility of the applicant for membership, the Secretary-Treasurer shall refer the application to the Board of Directors for decision. Upon receiving the approval of the Secretary-Treasurer, or the Board of Directors, when the application has been referred to them for action, and the payment of the membership fee and dues, the applicant shall be enrolled as a member of the Association.

Section 3. The membership fee shall be set by the Board of Directors and shall be payable with the application for membership.

Section 4. The annual dues shall be set by the Board of Directors and shall be payable on or before January first of each year.

Section 5. Any member of the association in arrears for dues for more than one year shall cease to be a member of the association but may be restored without the formality of re-election by payment of all arrears including the current dues.

ARTICLE II—OFFICERS

Section 1. The officers of the Association shall be President, Vice-President, Secretary-Treasurer, Journal Editor and a Board of Directors.

The Vice-President shall be elected by the vote of the membership and his term of office shall be for one year beginning October first following his election. On the completion of his term of office as Vice-President he shall automatically become President for one year, or until his successor is duly chosen. The Secretary-Treasurer and the Journal Editor shall be elected by the Board of Directors for such term of office as the Board of Directors shall prescribe.

Section 2. The Board of Directors shall consist of ten members: six to be elected by the membership, the retiring President, the President, the

Vice-President, and the Secretary-Treasurer. The Secretary-Treasurer shall be an ex-officio member.

Two Directors shall be elected each year, whose terms of office shall be for three years. The terms of all Directors shall begin October 1, following election.

Section 3. The Board of Directors shall elect two members from the Association, who, with the Secretary-Treasurer as an ex-officio member, shall constitute the Journal Management Committee, which shall be responsible to the Board of Directors. The term of service of the elected members shall be at the discretion of the Board of Directors.

Section 4. The Board of Directors may constitute and appoint such committees not provided for in the By-Laws of the Association, as they may deem proper, from their own membership or from the membership of the Association.

Section 5. The Board of Directors shall have the authority to fill vacancies that may occur among the offices of the Association, such appointees to serve during the remainder of the unexpired term of the office in question.

ARTICLE III—DUTIES OF OFFICERS

Section 1. The President of the Association shall preside at all meetings of the Association and meetings of the Board of Directors and shall perform such other duties as pertain to that office. The Vice-President shall perform the duties of the President in the absence of the President.

Section 2. The Secretary-Treasurer shall have charge of the business management of the Association, shall have custody of the books and records of the Association, keep the minutes of all meetings of the Association and the Board of Directors, maintain a list of all members and subscribers, keep the funds of the Association, and make disbursements therefrom when properly authorized.

Section 3. The Journal Management Committee shall have the general supervision of the Journal. The Journal Editor under the general supervision of this Committee, shall have direct charge of all editorial details of the Journal.

Section 4. The Board of Directors shall pass upon all applications for divisions, sections, and student branches of the Association.

Section 5. The Board of Directors shall have full control of the business of the Corporation, and the title to all property and funds of the Association shall be vested in the Board of Directors. The Board of Directors shall have all the rights and powers vested in the Corporation by the laws of the District of Columbia.

ARTICLE IV—ELECTION OF OFFICERS

Section 1. On or before September 10, the Secretary shall mail to

each member a blank on which he shall be entitled to express his choice for each office to be filled. This blank shall give the report of the Nominating Committee which shall suggest the names of two members for each office to be filled. All ballots shall be counted by the Secretary and later verified by the President. In case no candidate has a majority by the first ballot, the tie shall be broken by the Board of Directors.

ARTICLE V—MEETINGS

Section 1. Meetings of the Association shall be held at the time and place fixed by the Board of Directors, but not less than one each calendar year shall be held. Notice of the time and place of meetings of the Association shall be given to all members not less than four weeks prior to the date of the meeting.

Section 2. Meetings of the Board of Directors shall be held upon call of the President provided, however, that not less than 10 days notice of such meeting shall be sent to each member of the Board of Directors.

Section 3. The quorum of any meeting of the Association shall consist of not less than ten per cent (10%) of the membership.

ARTICLE VI—ORGANIZATION OF DIVISIONS, SECTIONS AND STUDENT BRANCHES

Section 1. Professional groups based on geographical considerations to be known as divisions of the Association and to be organized by the members of the Association may be authorized by the Board of Directors when such action shall seem expedient. The officers of the division shall be a chairman, and such other officers as are provided by the division.

The divisions shall have the right to make by-laws for their own government which shall not be inconsistent with the charter and the by-laws of the Association.

Membership in divisions of the Association is open only to those regularly elected members of the Association.

Any division may raise or collect funds to be expended for its own purpose.

Section 2. Professional groups based upon specialized interests to be nown as sections of the Association and to be formed by not less than ten mbers may be authorized by the Board of Directors when considered e best interests of the Association.

sections may elect their own officers and may make rules for their own ance not inconsistent with the charter and by-laws of the Association.

Section 3. Student branches at any agriculture college may be authorized by the Board of Directors on petition from at least ten students regularly enrolled in a four-year course in agriculture and majoring in

some phase of the dairy industry when their petition is recommended by two department members who are members of the Association.

ARTICLE VII—JOURNAL OF DAIRY SCIENCE

Section 1. The Journal of Dairy Science, published by the Association, shall be sent to each member, provided his dues are paid by January 10.

ARTICLE VIII—AMENDMENTS

Section 1. These by-laws may be amended at any meeting of the Association by an affirmative vote of two-thirds of those members present, provided that not less than 10% of the membership is present at the meeting.

All amendments must be referred to the Board of Directors for its recommendation prior to the final action by the Association. The Board of Directors may, at its discretion, submit proposed amendments which have received the approval of the Board, to the members of the Association for vote by mail. In such case, an affirmative vote of two-thirds of all voting, and which shall not be less than a majority of the membership, shall be necessary for approval.

Mr. O. F. Hunziker, chairman of the Journal Management Committee, gave a summary of the report which he had submitted to the Board of Directors. Upon motion duly seconded this report was approved.

Vice-President Weaver, chairman of a committee appointed to formulate a procedure whereby the sections and groups of the Association may secure Association approval of their actions before such actions are released for publication, submitted the report for the committee and upon motion duly seconded it was adopted. (Report will be found in minutes of the Board.)

J. A. Nelson submitted his report on junior chapters of the A. D. S. A. Upon motion duly seconded the report was adopted.

H. A. Ruehe, chairman of the Nominating Committee, submitted the following report:

The Committee on Nominations present the following nominations:

Vice-President	*Director*
E. S. Guthrie, Ithaca, N. Y.	M. E. Parker, Chicago, Ill.
J. A. Nelson, Bozeman, Montana	W. D. Dotterer, Chicago, Ill.

Director

C. S. Rhode, Urbana, Ill. J. W. Linn, Manhattan, Kansas

Respectfully submitted,

H. A. Ruehe, *Chairman* H. F. Judkins
D. R. Theophilus J. B. Fitch
K. M. Renner

Upon motion duly seconded the report was adopted and the committee discharged.

In the absence of Mr. H. P. Davis, Mr. H. C. Jackson submitted the report of the Resolutions Committee. The following report was read:

RESOLUTIONS

Whereas the American Dairy Science Association assembled at their thirty-third annual meeting at the Ohio State University has enjoyed a splendid program and many fine courtesies extended by faculty members of the various departments and their wives:

Therefore, Be it resolved:

That the membership of the American Dairy Science Association, their wives and families, wish to express their grateful appreciation to the staff of the Ohio State University, their wives and other organizations responsible for this entertainment.

Whereas the Borden Company has seen fit to continue their awards for outstanding research in the field of dairying:

Therefore, Be it resolved:

That the American Dairy Science Association again express its appreciation of this interest in dairy research.

Whereas from time to time variations in the manipulation of the Babcock test have been proposed:

Therefore, Be it resolved:

That the American Dairy Science Association make a comprehensive examination of the Babcock procedure for determining fat in milk and cream with the purpose of refining the technique, obtaining greater accuracy, reliability and uniformity without undue increase in complexity.

Whereas the Council on Foods of the American Medical Association has added oleomargarine to the approved list of foods and has removed butter from the same, and whereas all results of scientific investigation have shown the nutritional superiority of butter:

Therefore, Be it resolved:

That the American Dairy Science Association request the American Medical Association to request its Council on Foods to reconsider this action which may have such far reaching effects on a basic food industry.

Whereas the untimely passing of three of our esteemed members, Prof. E. B. Fitts of the Pennsylvania State College, Prof. Rush B. Locke of the Colorado State College, and E. S. Raven of the Raven Creamery, Portland, Oregon, has occurred during the past year, and whereas a keen sense of loss is felt by members of the American Dairy Science Association.

Therefore, Be it resolved:

That a recognition of this feeling be spread upon the records of the Association, and that the Secretary forward a copy of this resolution to the families of the deceased.

Whereas Dr. A. C. Dahlberg has asked to be relieved as editor of the JOURNAL OF DAIRY SCIENCE:

Therefore, Be it resolved:

That the membership of the American Dairy Science Association expresses its deepest regret that Doctor Dahlberg has felt it necessary to resign as editor of the JOURNAL OF DAIRY SCIENCE, a position which he has so bril-

liantly filled. The American Dairy Science Association further expresses its keenest appreciation of Doctor Dahlberg's ability as a scholar and scientist and its tribute to the great service rendered by him to this Association as Journal Editor.

Whereas the New York State Agriculture Experiment Station through its director has permitted Dr. A. C. Dahlberg to act through these years as Editor of the JOURNAL OF DAIRY SCIENCE:

Therefore, Be it resolved:

That the American Dairy Science Association express to Director Parrott and through him to the station, in regretfully accepting Doctor Dahlberg's resignation, its very great appreciation of the facilities provided and for giving the cooperation which has been so generously and graciously accorded the Journal Editor's office.

Respectfully submitted,
H. C. JACKSON
FORDYCE ELY
E. V. ELLINGTON
H. P. DAVIS

Upon motion duly seconded the report was adopted and the committee discharged.

The Secretary read the minutes of the Board of Directors and upon motion duly seconded the minutes were approved, and all action of the Directors during the past year were authorized and approved.

MEETING OF THE BOARD OF DIRECTORS
AMERICAN DAIRY SCIENCE ASSOCIATION
COLUMBUS, OHIO, JUNE 13, 1938

A meeting of the Board of Directors of the American Dairy Science Association was held in Townshend Hall, Monday evening, June 13, at 7:30 P.M. Present:—Pres. H. W. Gregory, Directors E. G. Hood, C. R. Gearhart, J. A. Nelson, C. E. Wylie, E. V. Ellington, H. Macy, and R. B. Stoltz. Absent:—Vice-President Earl Weaver and Director R. R. Graves.

O. F. Hunziker, chairman of the Journal Management Committee, appeared before the Board and gave a very comprehensive report discussing Journal finances (the additional annual cost for publication of abstracts of the literature on dairy cattle); recommendations for successor to Journal editor; budget for the office of editor; publication of abstracts of literature on dairy cattle; abstracts of annual meeting (one month in advance of the date of the meeting)—"Incidentally an unfortunate error occurred in the paging of the May issue of the Journal containing the abstracts of the annual meeting. The entire issue is paged for abstracts of literature instead of for main Journal text, as it should have been. This places the program and the original papers (abstracts of annual meeting) in the Abstract Section, which regularly consists of previously published material.

"This error which occurred during the Editor's absence due to serious illness, obviously cannot be undone. It is proposed, however, that this

material in the May Journal be considered for this year only in the Abstract Section. At the end of the year it will then be indexed in both the Abstract Section and in the section for original articles. While this makes the index for the section of the original articles somewhat cumbersome, confusion can be and will be avoided by using the letter "A" in front of the page and placing a footnote at the bottom of each page, stating that "A" refers to the Abstract Section.

"We propose also to make an announcement of this error at the General Session of this annual meeting, explaining to the membership the manner in which the matter will be taken care of. It was suggested that an insert be placed in the July issue making a statement regarding the renumbering of the pages."

Mr. Hunziker further discussed bids for printing the Journal; Reprints of chemical and bacteriological methods—"In the past the Chairman of the Committee on Laboratory Methods ordered a supply of reprints for distribution among members who wanted copies at 50¢ per copy, and the cost of these reprints was charged to the Journal with the understanding that after the committee chairman had sold a sufficient number, the Journal would be reimbursed out of such sale. As time went on the chairman developed a small fund which was maintained by the Committee to purchase reprints as issued.

"This appeared to work fairly satisfactorily but this service could obviously be improved by assisting the members in ordering reprints direct from the source of supply. In order to place this whole matter of reprints of chemical and bacteriological methods on a somewhat more business-like basis, your Committee recommends:

"1. That those interested in reprints on laboratory methods order the same direct from the Secretary-Treasurer, accompanying their order with remittance of the price per copy.

"2. That this change take effect at once.

"3. That announcement of this change be made at the general session of this annual meeting as well as in each issue of the Journal in which laboratory methods appear.

"4. That the chairmen of the Committees on Laboratory Methods be requested to transfer the fund that they may have accumulated from former sales of reprints to the Secretary-Treasurer.

"5. That the reprints in the hands of the chairman be transferred to the office of the Secretary and their availability be called to the attention of the members."

Further discussion covered insurance on back numbers of the Journal; publication of committee reports as follows:—"The Suggestion that committee reports of importance be published in the Journal originated with our Editor, Dr. Dahlberg. Your committee is heartily in favor of this

suggestion and we recommend it to this Board for consideration and approval. In the case of the Committee on Laboratory Methods, for instance, it is mandatory by vote of our Association, that reports after they have been accepted, be published in the Journal.

"There are other committee reports which are more or less official for our Association, and which are sufficiently important to merit a place in the Journal for similar reasons as prominence is given to any other original article. This would be true of reports for instance on dairy products standards, breed relation score cards and many other reports of similar importance.

"Your Committee, therefore, recommends that the Board of Directors, in case they are favorable to this suggestion, direct the committees of the Association to send their reports, after they have been finally approved by the Association, to the Journal Editor for publication in the Journal."

The concluding point concerned donations to other Journals.

Respectfully submitted,
A. A. Borland
R. B. Stoltz
O. F. Hunziker, *Chairman*

Mr. Ellington moved and Mr. Gearhart seconded that the Board of Directors accept the resignation of Dr. Dahlberg and send him our regrets that he could not be present and to send the Board's appreciation of his services. Motion carried, and the following telegram was sent to him:

"It is with sincere regret that we received and accepted your resignation as Editor of the Journal of Dairy Science. We deeply deplore your unavoidable absence from our annual meeting due to ill health that is preventing you from receiving, in person, our expression of appreciation and our tribute to the great service you have rendered our Association as Journal Editor. Accept our earnest good wishes for your speedy and complete recovery."

Board of Directors
American Dairy Science Association

It was moved by Mr. Wylie and seconded by Mr. Ellington that Dr. T. S. Sutton be employed as Editor of the Journal beginning July 1, 1938. Motion carried unanimously.

Mr. Nelson moved and Mr. Hood seconded that the Secretary be instructed to write to the Director of the New York State Agricultural Experiment Station the appreciation of this Board for making it possible for Doctor Dahlberg to serve as Editor and permitting clerical assistance for carrying on the work of the Editor of the Journal of Dairy Science during the past ten years. Motion carried. The following letter was sent:

"In accepting with regret Dr. A. C. Dahlberg's resignation as Editor of the Journal of Dairy Science, we desire to express to you our sincere appreciation and gratitude for the high privileges, helpful facilities and generous cooperation that the New York State Agricultural Experiment Station so freely accorded our Journal Editor's office for the lasting benefit of the Dairy industry."

BOARD OF DIRECTORS
American Dairy Science Association

Mr. Macy moved and Mr. Ellington seconded that the report pertaining to "reprints of chemical and bacteriological methods" be approved. Motion carried. Mr. Macy moved and Mr. Wylie seconded that the recommendation of the Journal Management Committee on publication of committee reports be approved as amended. Motion carried. Secretary Stoltz moved and Mr. Macy seconded that the report of the Journal Management Committee referring to donations to other Journals be approved. Motion carried. Mr. Macy moved and Mr. Wylie seconded that the report of the Journal Management Committee as amended be accepted. Motion carried.

The President appointed a committee to draw up a set of by-laws to replace our present by-laws, consisting of S. M. Salisbury, R. R. Graves, C. L. Roadhouse and R. B. Stoltz. These by-laws were submitted to the Board of Directors, and upon motion by Mr. Nelson and seconded by Mr. Wylie, it was recommended that the by-laws, as amended, be submitted to the membership for their approval. Motion carried.

The by-laws will be found printed in the minutes of Business Meeting.

President Gregory had previously appointed Mr. Macy to make a study of the rules concerning the Borden Award. He gave a report to the Board of Directors telling of how other associations handled similar awards. Mr. Wylie moved and Mr. Nelson seconded that President Gregory appoint a committee of three to draw up rules for the Borden Award. Motion carried. President Gregory appointed Mr. Macy, Mr. H. A. Ruehe and F. B. Morrison. The Board then adjourned.

MEETING OF THE BOARD OF DIRECTORS

COLUMBUS, OHIO, JUNE 14, 1938

A meeting of the Board of Directors of the American Dairy Science Association was held in Campbell Hall, Room 203, Tuesday, June 14, 1938, at 4:30 P.M. Present:—Pres. H. W. Gregory, Vice-Pres. Earl Weaver, Secretary Stoltz, E. G. Hood, C. E. Wylie, C. R. Gearhart, R. R. Graves, E. V. Ellington, and J. A. Nelson. Absent:—H. Macy.

Professor C. N. Shepardson of Texas appeared before the Board and extended the Association an invitation to hold their 1940 annual meeting in Texas. No action taken.

P. F. Sharp, chairman of the Committee on the Standardization of Market Milk, appeared before the Board and recommended the approval of the following report:

REPORT OF COMMITTEE ON STANDARDIZATION OF MARKET MILK
OHIO MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION,
JUNE 14–17, 1938

A committee of the American Dairy Science Association was appointed by H. A. Ruehe and continued by R. R. Graves, Presidents of the Association, to make recommendations regarding the mechanical standardization of market milk. At the meeting held in Lincoln, Nebraska, June, 1937, the recommendation of the committee was adopted, that a copy of its report be given to the members of the American Dairy Science Association as a preliminary to its consideration at the Ohio meeting.

Believing: that laws and regulations prohibiting the standardization of the fat content of market milk are unsound in principle as a means of protecting the consumer, and that legalization of the mechanical standardization of the fat content of market milk would remove an important economic restriction which operates to the mutual disadvantage of the farmer, the distributor and the consumer; the American Dairy Science Association approves and recommends in principle the following:

First: the legalization of the alteration of the fat content of market milk by mechanical standardization either up or down, by an amount not to exceed 0.6 per cent of fat, provided that all products used in standardization be at least equal in sanitary and physical quality and be held not longer than the milk to be standardized, and provided either that the minimum guaranteed fat content be stated on the label, or that classes or grade designations based on fat content be established and the class or grade designations corresponding to the legally established minimum levels of fat content be stated on the label.

Second: that the legal minimum for the solids-not-fat of milk be 8.15 per cent.

Third: That the legalization of the mechanical standardization of the solids-not-fat content of market milk by the addition of dried or condensed milk is inadvisable at this time.

A. D. Burke
W. D. Dotterrer
J. H. Frandsen
C. L. Roadhouse
P. F. Sharp, *Chairman*

Upon motion duly seconded the report was approved and referred to the membership for their action. The motion carried not unanimously.

The meeting then adjourned.

MEETING OF THE BOARD OF DIRECTORS
COLUMBUS, OHIO, JUNE 15, 1938

A meeting of the Board of Directors of the American Dairy Science Association was held in Townshend Hall, Wednesday, June 15, 1938, at 4 P.M. Present:—President H. W. Gregory, Vice-Pres. Earl Weaver, Secretary R. B. Stoltz, Directors J. A. Nelson, E. G. Hood, R. R. Graves, C. R. Gearhart and E. V. Ellington. Absent:—Directors H. Macy and C. E. Wylie.

The Secretary-Treasurer submitted the financial report which was sent to all directors in the month of February. Upon motion by Mr. Weaver and seconded by Mr. Graves this report was accepted and referred to the Auditing Committee. The report of the Auditing Committee was then read. Upon motion duly seconded the report of the Auditing Committee was accepted and referred to the Association. (Auditing Committee report may be found in minutes of the business meeting.)

G. M. Trout then appeared before the Board and requested the Board to give authority to the Dairy and Ice Cream Machinery and Supplies Association to publish the report of the judging of dairy products prepared by Mr. Trout in the Association Quarterly magazine. Upon motion duly seconded the Board of Directors approved the request.

Mr. Gearhart moved and Mr. Nelson seconded that the time of meeting at Washington and Idaho in 1939 be the week of June 26. Motion carried.

Mr. Nelson then reported on Student Branches of the A.D.S.A. Mr. Nelson moved and Mr. Graves seconded that the President appoint a committee of three to formulate a plan of junior chapters of the A.D.S.A. Motion carried. The President appointed Mr. Nelson of Montana, Mr. Ellington of Washington and Mr. Borland of Pennsylvania.

Mr. Weaver was then called upon to present a report of the committee appointed to formulate a procedure for various sections and groups of the Association. The report follows:

TENTATIVE REPORT

A committee consisting of J. A. Nelson, C. R. Gearhart and Earl Weaver was appointed by Pres. R. R. Graves in June 1937 to formulate procedure for various sections and groups of the Association to use in securing Association approval of such actions of these sections and groups as require such approval prior to their release for publication.

The committee proposes:

(1) Policy

(a) The action of any section or group which establishes grades or standards, prescribes methods for the conduct of tests or determinations, establishes regulation or in any other manner possesses

general interest may be published in such manner as deemed advisable subject to the approval of the Association in accordance with the provisions below.

(b) Association approval shall be construed as the favorable action of the membership in annual meeting or in cases of emergency of the favorable action of the Board of Directors. The decision as to the existence of an emergency shall rest with the President of the Association.

(c) No action of any section or group shall be purported to carry the Association approval until such approval has been granted.

(d) No action of any section or group shall be published in the Journal of Dairy Science until the Association shall have given its approval for such publication.

(e) Final judgment in respect to the advisability of publication in the Journal of Dairy Science of any action of the Association or of its sections and groups shall rest with the Board of Directors.

(2) Organization

(a) At the beginning of the Association year on October 1 the President shall appoint a general resolutions committee of five members to serve for that year.

(b) At the opening general session of each annual meeting the President shall have announced the time and place of the first meeting of the general resolutions committee.

(c) The chairman of each section and group shall be notified in advance of such subsequent meetings of the general resolutions committee as its chairman shall call during the period of the annual meeting.

(d) The general resolutions committee may submit a partial report at any general session during the annual meeting.

(3) Procedure

(a) It shall be the duty of the secretary of each section or group to transmit to the general resolutions committee or some member thereof, the action of his section or group upon which it is desired to receive Association approval.

(b) The general resolutions committee shall exercise its authority to reject the action thus transmitted or to submit it for the approval of the Association.

(c) Any member may submit from the floor of any meeting any matter upon which he desires to obtain Association action.

Signed: EARL WEAVER, *Chairman*
C. R. GEARHART
J. A. NELSON

Upon motion by Mr. Nelson and seconded by Mr. Ellington the report of the committee was approved.

MEETING OF THE BOARD OF DIRECTORS
COLUMBUS, OHIO, JUNE 16, 1938

A meeting of the Board of Directors of the American Dairy Science Association was held in Townshend Hall, Thursday, June 16, 1938 at 1:00 P.M. Present:—Pres. H. W. Gregory, Vice-Pres. Earl Weaver, Secretary Stoltz, E. G. Hood, J. A. Nelson, R. R. Graves, C. R. Gearhart. Absent:—C. E. Wylie and H. Macy.

The Program Committee gave the following report:

The Program Committee consisted of E. N. Shultz, W. E. Krauss, C. J. Babcock, with T. S. Sutton as Chairman; S. I. Bechdel and H. P. Davis were advisory members. The change in personnel of this committee from that of previous committees was made following a recommendation of the Program Committee of 1937. The present arrangement did not remove all the objections to the previous method of selecting the personnel of this committee. The other members of the committee are still located at considerable distance from the place of meeting. This year we were fortunate in having the chairman of the Production Section in this State and the chairman of the Manufacturing Section designated a member of the local Department of Dairy Technology to act for him in selecting and organizing papers for the Manufacturing Section.

The present Program Committee was handicapped for time. The Board of Directors adopted a resolution presented by the 1937 program committee, setting April 15 as the latest day for receiving titles and abstracts. A report of this action was published in the December issue of the Journal. The Journal Editor called for the program material on April 15, in order that it could appear as the May issue of the Journal.

Prior to April 15, the general program was organized and a definite time allotment set for papers voluntarily submitted. Papers were slow coming in; however, by the evening of the 15th, more papers than could be included in the time allotted were at hand. The recommendations of the 1937 program committee adopted by the Board of Directors provided means for making our decision on papers which were not included in the program. Papers which were received late (after April 15) were either included among those read by title or returned to the authors. Our program was organized, copied and in the mail to the Editor, April 16.

The present committee set the precedent in not including on the program all the papers submitted. The majority of the papers in the "read by title" group were so placed because of late arrival or duplication of authorship. For real effectiveness of the program, most eliminations should be made on the basis of the quality of the offering. We trust that future committees will be able to make more of their decisions on this basis.

The present program includes as special features, a symposium on nutrition, an education section and a general session at the Ohio Agricultural Experiment Station. Because of a lack of room facilities at the Experiment Station, it was impossible to schedule sectional meetings, and a program of general interest with invited speakers was decided upon. Our Wooster guests will have some time to inspect the experimental work in progress at the Station.

Because of the interest in artificial insemination an additional session of the Extension Section was scheduled for the discussion of this subject.

In order that the program committee may have more time for the careful consideration of the abstracts in making up the program, we recommend, that the last date for receiving abstracts be set some time in advance of the time the program must be submitted to the Editor. Such a date should be worked out by the chairman of the Program Committee and the Editor.

E. N. SHULTZ
W. E. KRAUSS
C. J. BABCOCK
T. S. SUTTON, *Chairman*

The meeting of the Board of Directors was then adjourned.

AMERICAN DAIRY SCIENCE ASSOCIATION PRESENTED BORDEN AWARDS TO K. G. WECKEL AND W. E. KRAUSS

AT THE

ANNUAL BANQUET

NEIL HOUSE

COLUMBUS, OHIO, JUNE 16, 1938

S. M. Salisbury, toastmaster, presented the officers and distinguished guests. He then introduced H. A. Reuhe, chairman of the Dairy Manufacturing Awards Committee, who made the following statement:

The Committee on the Borden Award in Dairy Manufacturers submits the following report:

According to the rules adopted by the Executive Board of the American Dairy Science Association, the Borden Award in Dairy Manufactures is awarded for outstanding research in the processing field such as improvement in equipment or methods in the handling of milk or cream and the production of milk products. The recipient must not have reached his fortieth birthday.

Your committee adhered rigidly to these rules in its consideration of nominees.

Your committee is pleased to announce that it has selected Dr. Kenneth G. Weckel, Dept. of Dairy Industry, University of Wisconsin, as the recipient of the Borden Award in Dairy Manufactures for the year 1938.

Doctor Weckel was selected on the basis of the significant contributions which he has made in the application of irradiation to the commercial dairy industry. He is responsible for the development of apparatus which has made the irradiation of milk commercially possible.

Doctor Weckel was born in Canton, Ohio, in 1906. He received his undergraduate training at the University of Wisconsin and was graduated with the Bachelor of Science degree with honors in 1931. He was granted the Master of Science degree in 1932, and the degree of Doctor of Philosophy in 1935 by this same institution.

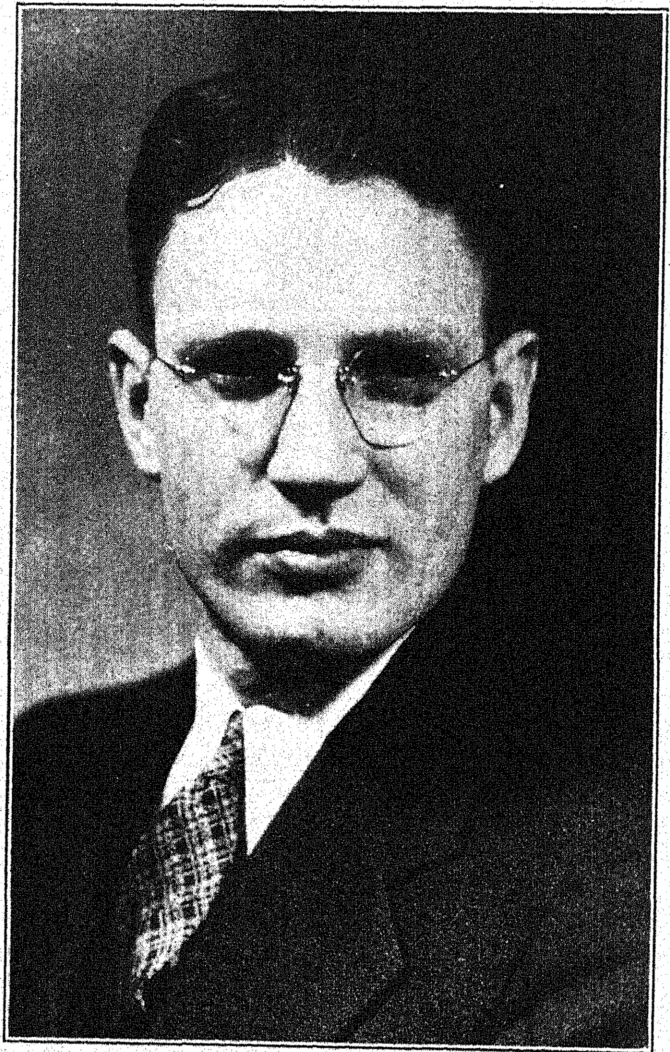
Doctor Weckel has devoted his attention to the study of light and its relation to the vitamin D potency of dairy products. He is an authority in this field. The results of his research have appeared in many articles published both in scientific journals and trade papers. In all of his writings, as in his research, he has kept the practical application of his studies in mind, making it possible for the commercial industry to keep abreast with his scientific findings.

Dr. Kenneth G. Weckel has brought honor to himself and to the institution of which he is a member through his efforts and his desire to serve the dairy industry to the best of his ability.

Respectfully submitted,

M. E. PARKER H. L. RUSSELL

H. A. RUEHE, *Chairman*



KENNETH G. WECKEL

"Mr. Wentworth, it is now my pleasure to present to you as the recipient of this Award, Dr. Kenneth G. Weckel."

Mr. W. A. Wentworth, representing the Borden Company, then spoke as follows:

"Dr. Weckel, on behalf of The Borden Company I present this medal to you which is given in recognition of the fine work you have done in research.

"So that you and all those present may know the message which is conveyed with this medal, I should like to read from its reverse side:

> Award for Outstanding Achievement in Dairy Manufacturing Research to *Kenneth G. Weckel, 1938,* by Direction of American Dairy Science Association.

"Along with the medal goes a financial reward which we trust will be of value to you and possibly afford you an opportunity to possess some things which might not otherwise be available to you.

"The purpose of this award in addition to rewarding and recognizing you as an individual is to stimulate in others, the hundreds of them who are engaged in similar work throughout the United States and Canada, further constructive research in the dairy manufacturing field for the advancement of the industry.

"Dr. Weckel again on behalf of The Borden Company, I wish to congratulate you upon your own attainments which tonight are recognized by the American Dairy Science Association and particularly by those of that Association who are here tonight and who have so grandly indicated their concurrence in the grant of the award to you."

The toastmaster then introduced F. B. Morrison, chairman of the Production Award Committee, who gave the following report:

The Dairy Production Award Committee of the American Dairy Science Association, whose function it is to select the person to receive the Borden Award in the field of dairy production, has unanimously chosen Dr. William E. Krauss, of the Ohio Agricultural Experiment Station at Wooster, Ohio, for this honor on account of his important and able investigations in this field.

It was no small task for the members of the Award Committee to select the person to receive this award from the several who had been recommended for our consideration by the Nominating Committee or who had been proposed to us directly by other members of our Association. This was because several men had been suggested who had done important research work of a high grade in the field of dairy production.

Each member of the Award Committee considered, entirely independently, the information available concerning each person who had been nominated, including his research publications. Without any knowledge

WILLIAM E. KRAUSS

of how the other members of the Committee had ranked the nominees, each of us arrived at a definite ranking. Fortunately, when we compared by correspondence our decisions, we found that we had each placed Doctor Krauss in first rank.

We selected Doctor Krauss for this honor primarily because of the extensive investigations in which he has been the leader, upon the nutritive value of milk and upon factors affecting its quality and value. Doctor Krauss has not only obtained in these researches much information which is of great importance to the dairy industry, but he has also carried this information to the dairy industry by means of publications of a popular nature and addresses before various dairy organizations.

Among the important investigations by Doctor Krauss in this field are the following: The comparisons of various methods of increasing the vitamin D potency of milk, including studies of the cost with various methods. Extensive studies on the effects of pasteurization on the nutritive properties of milk in which it was concluded that "The nutritive deficiences of pasteurized milk (vitamin B and C) can be readily overcome by proper dietary control, and the continued use of pasteurized milk offers no serious problem from the food standpoint." Investigations of the effect produced upon the carotene content and other biological properties of milk, by feeding legume and grass silage.

Due consideration was also given to the joint investigations conducted in the field of dairy production by Doctor Krauss and his colleagues—Professors Hayden, Sutton, Bethke, Monroe and Perkins. These have included the extensive studies on the vitamin A and carotene content of the butterfat produced by various breeds of cows, on the use in dairy rations of fish meal and products containing fish meal, on methods of raising dairy calves on dry calf meals, and on such practical management problems as box stalls vs. tie and stanchion stalls for milk cows.

On account of the services of Doctor Krauss to the dairy industry in these several investigations, the Award Committee takes pleasure in presenting him to Mr. Wentworth, of The Borden Company, to receive the Borden Award in Dairy Production for 1938.

H. B. Ellenberger
C. W. Larson
F. B. Morrison, *Chairman*

"Mr. Wentworth, it is with pleasure that I present to you Dr. W. E. Krauss, the recipient of the Dairy Production Award."

Mr. Wentworth then spoke, "On behalf of The Borden Company and with a feeling of personal pride because of my acquaintance with you, I wish to present you with this much deserved award for the work you have done in scientific research.

"Like I did in the preceding presentation, I should like to read to you and for the benefit of those gathered, the inscription on the reverse side of the medal:

> Award for Outstanding Achievement in Dairy Production Research to *Dr. William E. Krauss, 1938,* by Direction of American Dairy Science Association.

"What I said in the previous presentation regarding the recognition of its recipient and the hope which The Borden Company has that it will stimulate further research and progress in this industry, applies equally in your case.

"The Borden Company congratulates you on the success you have attained and I add my own best wishes."

The presentation of Awards was completed at 9:00 P. M., and the rest of the evening was given over to visiting, card playing and dancing.

GENERAL PROGRAM

Ohio Agricultural Experiment Station
Wooster, Ohio, June 17, 1938

Mr. C. C. Hayden introduced Vice-Pres. Weaver at 10:45 A. M., as chairman of the morning's program. Director Edmund Secrest of the Ohio Agricultural Experiment Station was then introduced and gave an address of welcome. The program was followed as scheduled by the program committee except that in the absence of Dean Anthony, Mr. Balser read his paper.

Chief O. E. Reed of the Bureau of Dairy Industry was called upon and gave a very short and interesting message regarding the benefits one may derive by attending these meetings.

There were 154 in attendance.

After lunch was served a visit was made to observe the herd, farm and laboratories.

VOLUME XXI AUGUST, 1938 NUMBER 8

JOURNAL OF DAIRY SCIENCE

Published by the

AMERICAN DAIRY SCIENCE ASSOCIATION

R. B. STOLTZ
Ohio State University, Columbus, Ohio, Sec.-Treas.

ABSTRACTS OF LITERATURE

T. S. SUTTON, Editor
Geneva, New York

MILK AND MILK PRODUCTS

Published in cooperation with

INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS
R. C. HIBBEN, 1105 Barr Bldg., Washington, D. C., Exec. Sec.

INTERNATIONAL ASSOCIATION OF MILK DEALERS
R. E. LITTLE, 309 W. Jackson Blvd., Chicago, Illinois, Exec. Sec.

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Carpenter, D. C.
Cave, H. W.
Clevenger, W. L.
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Fabian, F. W.
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Endocrinology

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Journal of Heredity
Journal of Genetics
Journal of Infectious Diseases
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Journal of Milk Technology
Journal of Nutrition
Journal of Pathology and Bacteriology
Journal of Physical Chemistry
Journal of Physiology

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Kolloid-Zeitschrift

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Proceedings of Society of Animal Production
Proceedings of Society of Experimental Biology and Medicine

Tierernährung
Tierzüchter
Trudy Vologodskogo Molochnogo Institut

Zeitschrift für Infektionskrankheiten Parasitäre Krankheiten und Hygiene der Haustiere
Zeitschrift für Physikalische Chemie, Abt. A and B
Zeitschrift für Untersuchtung der Lebensmittel
Zeitschrift für Züchtung. Reihe B. Tierzuchtung und Zuchtungbiologie
Zentralblatt für Bacteriologie
Züchtungskunde

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

315. Standard Agar Counts as Compared with Counts on Improved Agars at 32° C. M. W. YALE, N. Y. Agr. Exp. Sta., Geneva, N. Y. Am. J. Pub. Health *28*, 2, p. 148, 1938.

Data collected by 56 laboratories showing comparative agar plate counts of 23,715 samples of dairy products are summarized. The advantages to be gained through the use of an improved agar and an improved incubation temperature are discussed. M.W.Y.

316. Disintegration of Paper Board for Bacteriological Examination. J. R. SANBORN, N. Y. Agr. Exp. Sta., Geneva, N. Y. Am. J. Pub. Health *28*, 5, p. 576, 1938.

The technic used for the disintegration of paper board for determination of total bacterial counts is described. The apparatus consists of an electrically operated food mixer with double propellors which exert a beating action on the fibers. The paper is reconverted to a uniform pulp suspension suitable for distribution in ordinary Petri plates. The technic has been used in connection with studies of paper milk containers. M.W.Y.

317. Suitable Paper Wrappers and Containers for Foods. J. R. SANBORN, N. Y. Agr. Exp. Sta., Geneva, N. Y. Am. J. Pub. Health *28*, 5, p. 571, 1938.

The sanitary control of paper milk containers and paper containers for foods in general is discussed. Topics included are (1) fundamental requirements for the production of paper of satisfactory sanitary quality; (2) types of microorganisms in container board; (3) bacterial counts of container board; (4) sanitary standards for container board; (5) handling of clean wrappers and container board and (6) examination of fabricated paper containers for milk. M.W.Y.

318. Microbial Flora of Paper Containers. FRED W. TANNER, Laboratories of Bact. of Univ. of Ill., and American Can Co., Maywood, Ill. Am. J. Pub. Health *28*, 5, p. 587, 1938.

The author concludes that the average bacterial content of paper milk containers for distribution of fluid milk is much lower than the counts which have been reported for some glass bottles. The types of bacteria are usually sarcinae, white staphylocci, aerobic sporeforming rods, and non-spore forming rods. Such organisms are of no sanitary significance according to the author. M.W.Y.

319. Contribution to the Study of Lactic Bacteriotherapie. Lactic Ferments and Fermented Milks. ALEXANDER NEUKOMM, Nestle and Anglo-Swiss Condensed Milk Co., Vevey, Switzerland. Le Lait *18*, 174, p. 353, April, 1938.

The various organisms present in the cultures used in preparing such milks as Yoghourt, Koumiss, and others are described and the possible mechanism of lactic acid formation is discussed. The chemical composition of these milks is also reported. Forty literature citations are given.

A.H.J.

BREEDING

320. A Statistical Inquiry into the Inheritance of Milk Yield in Three Herds of Dairy Shorthorn Cattle. A. D. BUCHANAN SMITH. Jour. of Dairy Research *8*, 347–388. 1937.

The paper embodies an examination of the possibility of sex-linked genes affecting the transmission of milk yield. To reduce environmental effect the study was restricted to three herds of the English Dairy Shorthorn breed. Fisher's squared difference method was used. The lumped results indicate that the paternal grandsire has a lesser effect than the maternal grandsire. In this respect the figures for one herd did not agree with the other two. The subject is reviewed, and the author concludes that the accuracy of the conclusions which may be drawn from statistical studies of this type are not commensurate with the labor involved. S.T.C.

BUTTER

321. Use of Anti-oxidants to Prevent Tallowiness in Butter. W. J. CORBETT AND P. H. TRACY, Univ. of Ill., Urbana, Ill. Nat. Butter and Cheese J. *28*, 24, p. 10, Dec. 25, 1937.

The addition of 1 per cent Avenex (finely powdered oat flour) on a fat basis retards the development of oxidized flavors in butter. The addition of an aqueous filtrate of Avenex appears to be the most practical procedure of adding it to the cream. Avenex should be added to the cream after neutralization and before pasteurization. The addition of Avenol (an extract of oat flour with an oil solvent hexane) gave less positive results than did the Avenex. Wrapping prints in Avenized parchment (made by sizing parchment paper in oat flour solution) retards the development of surface flavors and improves slightly the keeping quality of the butter.

W.V.P.

322. What Needs to be Done to Increase the Consumption of Butter? L. C. THOMSEN, Univ. of Wisconsin, Madison, Wis. Nat. Butter and Cheese J. *29*, 2, p. 10, Jan. 25, 1938.

There is an apparent drop in butter consumption probably because people regard butter as fattening and expensive. Consumption may decrease still more with the declining proportion of children in the population and the increased advertising of butter substitutes. Butter advertising should stress that educators and doctors favor the use of butter. The adult population must be honestly convinced that butter is not expensive considering calorie and vitamin content and that when it is used intelligently it is not fattening. Improving the condition of milk production, methods of manufacture, flavor and color control should make advertising campaigns more effective. W.V.P.

323. Making No. 1 Butter from No. 2 Cream. L. P. SHARPLES, Milk Processes Inc., Philadelphia, Pa. Nat. Butter and Cheese J. *29*, 6, p. 7, Mar. 25, 1938.

"Plastic cream" is chilled cream with 80 to 83 per cent of butterfat. Compared to fluid cream it is cheaper to ship and store. It is made by passing heated fluid cream through a special centrifugal separator which removes curd, dirt (if the cream is neutralized), and nine-tenths of skimmilk. The bowl of the centrifuge is automatically self-cleaning. The cream is pasteurized after coming from the centrifuge and is passed over a special stainless steel drum cooler. There is no extra cost for making plastic cream when cream for storage is produced from whole milk. When fluid cream is received instead of whole milk the extra cost is estimated as one-eighth cent per pound. Plastic cream is used for making fluid cream, ice cream, cream cheese, flavored spreads and butter. W.V.P.

324. Technological Exploration of the Art of Buttermaking. M. E. PARKER, American Butter Inst., Chicago, Ill. Food Research *3*, 1 and 2, p. 261, Jan.–Feb., Mar.–Apr., 1938.

An interesting discussion is given of the keeping qualities of butter and some problems of manufacture. F.J.D.

325. The Determination of the Quantity of Diacetyl in Butter. R. DEHOVE AND L. DESSIRIER, Municipal Lab. of Lille, France. Le Lait *18*, 172, p. 150, Feb., 1938.

The usual methods of determining diacetyl based on the formation of dimethylglyoxime or of quinoxaline, or of xyloquinone were tested on 50 gram samples of butter but were not found sensitive enough for determining the diacetyl in this small quantity of butter. The dimethylglyoxime method was accordingly modified. Twenty cc. of distillate obtained from the 50 grams of butter were treated with 1 cc. of 10 per cent chlorhydrate of hydroxyamine followed by 2 cc. of normal soda solution. After agitation 1 cc.

of a 0.2 per cent solution of nickel sulphate was added and then 0.6 cc. of normal acetic acid. The whole solution was then transferred to a porcelain dish and evaporated on a water bath. The residue was taken up 3 times with 2 cc. of chloroform, the filtrate and washings were evaporated to dryness on a small white porcelain dish. The nickel dimethylglyoximate then deposited as a reddish violet coloration on the white porcelain. The quantity of diacetyl in the sample was then determined by comparison with the colors in test dishes prepared in the same manner from quantities of diacetyl varying from 0.05 milligram to 0.50 milligram corresponding to diacetyl contents of the butter varying from 1 to 10 milligrams per kilogram. Another method of determining diacetyl was also investigated depending on the intense color produced in sulphuric acid medium by pyrocatechol and resorcin in the presence of traces of diacetyl. A.H.J.

Other abstracts of interest are numbers 316, 317, 318, 344, 345, 351, 368, 369, and 371.

CHEESE

326. Buttermilk and Cottage Cheese. C. R. Nickolls, H. P. Hood and Sons, Inc., Boston, Mass. Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 11, 1937.

For cultured buttermilk pasteurization of skimmilk at 180°F. or more for 20 to 30 minutes is recommended. A system of carrying starters and three methods of producing butter granules are proposed. Little agitation and storage temperatures below 50°F. are emphasized.

In order to control texture and flavor of cottage cheese more accurately extracts or coagulators are recommended and the setting period is confined to 12 hours. The curd is cut just before wheying off occurs at near .8 per cent acidity. Stirring only every 15 or 20 minutes and other details in order to produce best results are specified. E.F.G.

327. Natural Cheese with Package Appeal. Anonymous. Nat. Butter and Cheese J. *29*, 1, p. 14, Jan. 10, 1937.

The mechanical method of making and packaging a soft-ripened type of cheese is described. Pasteurized-milk curd is formed into long slabs of uniform size and weight. These are cut into small loaves or bricks after curing. The treatment permits ripening with minimum rind development; reduces the cost of manufacture; and makes the cheese more attractive to the distributor and consumer. Patents for the special equipment have been granted to Raymond Miollis, Natural Cheese Inc., Chicago, Illinois.

W.V.P.

328. A Quality Improvement Program Proposed for the Wisconsin Cheese Industry. W. V. PRICE, Univ. of Wisconsin, Madison. Nat. Butter and Cheese J. *29*, 6, p. 18, Mar. 25, 1938.

A plan is suggested to secure compensation for the voluntary production of an approved or "certified" type of American cheese. Standards of production, manufacture and handling would be defined by an elected "Council" of industry members representing farmers, manufacturers and dealers. The cooperation of interested public health agencies would be invited in formulating these definitions. The Council would determine suitable compensation to producers for meeting these standards and would control the necessary inspection, branding and analytical services which would be paid for by participating factories. Costs of these services are estimated at approximately 0.2 cents per pound of approved cheese.

W.V.P.

329. Canning of Cheddar Cheese. L. A. ROGERS, Bureau Dairy Industry, U. S. Dept. of Agr., Washington, D. C. Food Research *3*, 1 and 2, p. 267, Jan.–Feb., Mar.–Apr., 1938.

The development of canned cheddar cheese is discussed together with its present status and future possibilities. F.J.D.

330. Utilization of Whey in Foods. B. H. WEBB, Bureau Dairy Industry, U. S. Dept. Agr., Washington, D. C. Food Research *3*, 1 and 2, p. 233, Jan.–Feb., Mar.–Apr., 1938.

The author discusses the work of the B. D. I. in attempting to find uses for cheese factory whey. Some success has been experienced in utilizing whey in certain cream soups, tomato juice, fruit mixtures and drinks and fruit whips. Sweetened condensed whey appears to offer interesting possibilities. F.J.D.

331. The Identification of Roquefort Cheese. G. GENIN, Paris, France. Le Lait *18*, 174, p. 372, April, 1938.

Genuine Roquefort cheese is made entirely from sheep's milk. Sheep's milk fat is characterized by a considerably higher caprylic and capric acid content. On the analysis of the fat this appears as a higher Polenske number. The higher Polenske number of the fat from cheese of the Roquefort type consequently indicates whether it has been made from cow's or from sheep's milk. Cheese fat having a Polenske number of 3 or lower indicates the cheese was not made from sheep's milk. The fat used in determining the Polenske number may be extracted with ether or allowed to drain from a warmed sample that has been well worked to soften it. The feed given the cows or sheep does not cause the difference in Polenske numbers of fats

from the two milks as even when cows and sheep receive the same feed there is the characteristic difference in Polenske numbers of the fats from the two milks. A.H.J.

Other abstracts of interest are numbers 351, 368, and 369.

CHEMISTRY

332. Action of Enzymes at Low Temperatures. A. K. BELLS AND HANS LINEWEAVER, U. S. Dept. of Agr., Washington, D. C. Food Research *3,* 1 and 2, p. 57, Jan.–Feb., Mar.–Apr., 1938.

The authors conclude that enzyme action at low temperatures not only takes place but is an important factor in food preservation. The velocity of reaction in some cases, especially with lipase, is surprising. In others it is so slight as to be detected with uncertainty. However, even in the latter cases the initial phase of the reaction may have been completed so that when the food is brought to ordinary temperatures again the spoilage occurs with greater rapidity. F.J.D.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

333. Advancement in Sterilization Methods for Canned Foods. C. O. BALL, American Can Co., Maywood, Ill. Food Research *3,* 1 and 2, p. 13, Jan.–Feb., Mar.–Apr., 1938.

The author presents a very complete historical review of the subject with bibliography, and list of patents, some of which deals with evaporated milk or with methods which might be applicable to evaporated milk, particularly "high-short sterilization" methods. F.J.D.

334. Distinctive Characteristics of Skimmilk Powders (Powders Soluble —Powders by the Hatmaker Process). JEAN PIEN, Lab. of the Farmers Union, Paris, France. Le Lait *18,* 174, 347, April, 1938.

Finely ground skimmilk powders prepared by the Hatmaker process have the same appearance as the more soluble powders made by the spray process. They may be distinguished, however, by their appearance under the microscope. Skimmilk powder, made by the Hatmaker process, consists of irregularly shaped plates, while spray powder is made up of spheres. When the two types of powder have been mixed, microscopic examination serves to detect such mixture. Spray powders are considerably more soluble than powders made by the Hatmaker process. When 10 grams of the latter powder is mixed with 100 cc. of water and allowed to stand, the precipitate will occupy 50 to 90 cc. Spray process powders similarly tested will show a precipitate of only 1 cc. or less. Skimmilk powders made by the Hatmaker

process are lower in bacterial count than spray skimmilk powders. The reduction time for methylene blue is accordingly much longer for the Hatmaker type of skimmilk powder. Reconstituted spray skimmilk powder sours after standing for a short time, while reconstituted Hatmaker powder may stand for several days without souring. A.H.J.

335. Artificial Wool from Casein. P. DIATCHENKO. Le Lait *18*, 175, p. 233, March, 1938.

The properties of casein of importance for its use in the making of synthetic wool are: the moisture content because of its effect on the stability in connection with subsequent dyeing, the fat content because of its effect on the quality of the textile fibers and on filtering the casein solution before casting the threads, the ash content because of the effect on the viscosity of the casein solution, and on the quality of the fibers, and the acidity because high acidities of the casein produce transformations in the properties of casein. The process of making synthetic wool involves the following steps—preparation of a casein solution, preparation of the fiber, construction of the thread, fixation of the thread and drying and finishing of the thread. Casein is usually dissolved according to 2 procedures—by ammonium hydroxide or by caustic soda plus carbon disulphide. The solutions produced by the two methods are filtered through cotton and then pass to machines where, under pressure, they are forced through small openings into the fixing solution containing acid and other compounds including formalin. After washing and drying, the fibers prepared in this manner have the appearance and feeling of wool. The synthetic wool prepared by the ammonia method is of greater fineness than natural wool or synthetic wools prepared by the carbon disulphid method or the Italian method. The resistance to pull and the extensibility of the synthetic wool prepared by the ammonia process approach more closely these properties of natural wool than do the synthetic wools prepared by the carbon disulphide method or by Italian Lanatal. A.H.J.

Other abstracts of interest are numbers 315, 336, 337, 342, 344, 345, 351, 368, and 369.

DISEASES

336. The Effect of Mastitis on the Udder and Its Product. T. S. SUTTON, Ohio State University, Columbus, Ohio. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 3, 1937.

The causal organisms and changes in the udder during the progress of the disease are outlined. Changes in the milk may be classified as physical, chemical and biological. The physical changes are those of consistency and

color or appearance. Chemically, mastitis milk usually shows an increase in chlorides, catalase, albumin, and pH, and a decrease in lactose and casein. The biological changes usually noted are increases in leucocytes and bacteria, the bacteria being chiefly long chain Streptococci. E.F.G.

337. The Composition of Milk as Affected by Mastitis. C. H. WHITNAH, W. J. CAULFIELD, A. C. FAY, AND V. D. FOLTZ, Kansas Agr. Exp. Sta., Manhattan, Kansas. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 19, 1937.

A numerical mastitis milk score is obtained based upon leucocyte and bacteria counts. These were compared with chemical determinations of minerals, sugar, protein, lecithin, lipase, phosphatase, carotene, flavin, and vitamin C, on 50 to 70 cows for a period of two years. The data confirm and extend to additional constituents the conclusion of other workers, that latent mastitis does not produce uniform serious changes in the composition of milk. E.F.G.

338. A Study of the Vaginal Content of Pregnant Bang-Infected Cows for the Presence of Brucella abortus. C. P. FITCH, W. L. BOYD, AND LUCILLE M. BISHOP, University of Minnesota, St. Paul, Minnesota. J. Am. Vet. Med. Assoc., N. S. *45*, 2, p. 171, Feb., 1938.

Examinations of swabs taken from the vagina of 58 reacting animals, indicate that *Brucella abortus* is not ordinarily found in the vagina of pregnant, Bang-infected cows until very shortly before an abortion or a normal parturition.

However, the organism appears in the discharges after the seal of pregnancy is broken. The investigators cautioned that the animals examined did not show noticeable discharges from the vagina and that animals showing such discharges might be exceptions. J.W.W.

339. Bang's Disease—Status of Vaccination. W. WISNICKY, Wis. Dept. of Agr. and Markets, Madison, Wis. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 72, 1937.

About 20 per cent of abortions in cattle are produced by causes other than infection with the Bang organism. In recent years it has been proved that the abortion bacterins are practically worthless in the control and treatment of Bang's disease. The virulent live culture vaccines do have some merit. However, they possess disadvantages which more than outweigh any good that they may have. In the use of the virulent live culture vaccine, the disease was actually introduced into herds that were free from the disease. More recent researches indicate that by the use of a moderately virulent strain of the Bang organism on young calves, a degree of immunity against the disease may be established. E.F.G.

340. Bang's Disease in Cattle. A. E. WIGHT AND J. M. BUCK, U. S. Dept. of Agr., Beltsville, Md. Ann. Conv. Intern. Assoc. Milk Dealers, p. 60, 1937.

Since July, 1934, when Federal funds were made available for conducting supervisory work in the field and making payments to owners whose cattle reacted to the test, steady progress has been made until at present 15.3 per cent of the cows of the United States are under supervision. During the fiscal year ended June 30, 1937, agglutination tests were applied to 8,000,000 cattle with 398,000 or 5 per cent reacting. The history of attempts to control the disease with vaccines and similar means is traced. Some success with calfhood vaccination under carefully controlled conditions with a vaccine from *Br. abortis* strain 19 has been attained under experimental conditions. E.F.G.

341. Pathological Changes Occurring in the Bovine Udder Due to Infectious Mastitis. W. T. MILLER, Bureau of Animal Industry, Beltsville, Md. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 5, 1937.

This study is restricted to the effects of cocci entering the udder through the teat canal. Examination of 304 udders showed 256 or 84 per cent were carrying streptococci in one or more quarters so that the study was largely one of lesions occurring in chronic streptococcus mastitis. The normal course of this infection was an infiltration of leucocytes followed by the formation of increasing quantities of connective and scar tissue with the ultimate almost complete disappearance of normal alveoli in longstanding cases of marked mastitis. The various conditions are illustrated with ten photomicrographs. E.F.G.

FOOD VALUE OF DAIRY PRODUCTS

342. The Nutritive Value of Milk Supplemented with Minerals as an Exclusive Diet for Rats. Comparison of Equal Volumes of Summer and "Winter" Milk Before and After Laboratory Pasteurization. K. M. HENRY, E. W. IKIN, AND S. K. KON. J. Dairy Research *8*, p. 282, 1937.

Milk was obtained simultaneously from cows on early pasture and from stall-fed cows receiving winter rations. By suitable blending of the morning's and evening's milkings of each milk the fat content of the two milks was equalized daily. A part of each milk was then pasteurized in the laboratory by a "holder" method. The total nutritive value of the milk was measured on rats in two separate experiments. In one the milks, supplemented with iron, copper and manganese, were fed as an exclusive diet.

The four types of milk were given to twelve groups of litter-mate male rats, the intake being equalized within each group. The experiment lasted 8 weeks, and at the end no difference was found in gain in weight, body length, general appearance of the rats or composition of the carcasses. The palatability of the milks as gauged by the refusals of the rats were investigated by various statistical methods, which showed that summer milk was probably more palatable than "winter" milk, but that pasteurization had no effect.

In the second experiment the intake of milk was limited to 20 ml. daily, but the rats were given in addition unlimited access to a basal diet of casein, sugar and salts. This experiment was also carried out on groups of four litter mates (four groups of does and seven groups of bucks). After 8 weeks 5 per cent brewer's yeast was added to the basal diet, resulting in a marked increase of the growth rate of all the groups. At the end of 8 weeks, the gains in weight, intake of basal diet, and gains per gram of solids ingested were compared. The only statistically significant differences were in favor of pasteurized summer milk when compared with summer raw and with "winter" pasteurized.

Taking both experiments into consideration it is concluded that they did not reveal any difference in the total nutritive value of the milks. S.T.C.

343. Carotene and Ascorbic Acid Content of Fresh Market and Commercially Frozen Fruits and Vegetables. G. A. FITZGERALD, Birds Eye Labs., Boston, Mass., AND C. R. FELLERS, Mass. Agr. Exp. Sta., Amherst, Mass. Food Research *3*, 1 and 2, p. 109, Jan.–Feb., Mar.–Apr., 1938.

Data showing that the vitamin content varies considerably between different fruits and vegetables and between the same ones grown or packed in different places. Vitamin A is almost totally retained during processing and freezing and also during storage. F.J.D.

344. The Nutritive and Safety Value of Pasteurized Milk. GORDON BATES, Health League of Canada, Toronto, Canada. Ann. Conv. Intern. Assoc. Milk Dealers, General Sessions, p. 11, 1937.

Experience of Toronto from health standpoint, where compulsory pasteurization has been in effect since 1915, is cited to indicate the effectiveness of pasteurization since not a single case of bovine tuberculosis infection has been encountered in this generation of children raised on pasteurized milk in Toronto. Also, among 100,000 children admitted to the hospital for sick children there has not been a single case of abdominal tuberculosis since inauguration of pasteurization. The progress of pasteurization in Canada and United States is discussed.

Evidence is given to indicate that the nutritive properties of milk are

not injured by pasteurization, and the author recommends that all milk be pasteurized. E.F.G.

345. The Status of Vitamin A as Related to Dairy Cattle. O. C. Copeland, Texas Agr. Exp. Sta., College Station, Texas. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 28, 1937.

Effects of vitamin A deficiency in feed upon vitamin A content of resulting butter are shown. Cows fed on cottonseed meal and hulls produced fat with 2½ units vitamin A potency per gram. With the above, plus sorghum silage, 12 per gram, whereas with pasture also added the butterfat contained 33 units per gram. On a vitamin A deficient diet, the most rapid decrease in potency of butterfat occurs during the first 60 days. Two cows fed a vitamin A deficient ration decreased from 40 units to 12 units per gram, but on 5 hours pasture daily came back to original 40 units at end of third day. It seems that green pasture is necessary for the production of butterfat which can be classed as high in vitamin A potency. Cows in such an advanced stage of vitamin A deficiency that they cannot gain their feet, recover rapidly when vitamin A is administered. E.F.G.

HERD MANAGEMENT

346. Die Bestimmung der Milchleistungsfähigkeit. (Measuring milk producing ability. Part 2.) L. Krüger. Züchtungskunde *13*(2), 49–63. February, 1938.

The average discrepancy between a cow's uncorrected record and her real producing ability is about 20 per cent of the record in data from cow testing associations in Silesia. In about one-fourth of the cases the discrepancy exceeds 40 per cent. Various methods of making these discrepancies smaller so that they will be less serious obstacles to successful selections are compared. It is not very practical to avoid all corrections by (1) absolute standardization of conditions beforehand, or (2) by providing physiologically optimum conditions for one or more "test" lactations, or (3) by selecting afterward those lactations made under conditions which happened to be "standard." Those procedures are sometimes helpful but often reduce the errors only a little and can rarely include more than about a quarter of all records, even when the range of conditions included as "standard" is made wider than is desirable. The use of correction factors (as for age, service period, lactation length, etc.) helps but is never complete and does not adjust for general conditions of feeding or management to which all cows of the herd are exposed. The method recommended is to correct the lactations to the production at a standard age during a calving interval of definite length (360 days) and with a dry period and preceding dry period of definite length, by means of suitable correction factors. Then this standard-

ized record is corrected for general conditions of feeding and management by comparing it with the production of other cows freshening near the same time in the same herd. It is claimed that the average discrepancy between a record corrected by Krüger's method and the cow's real ability is only about 9 per cent. J.L.L.

ICE CREAM

347. **"Maple—Favorite Food Flavor."** Frederick S. Morison. Food Ind. *10,* 3, p. 143, 1938.

This article is a discussion of the grades and uses of maple syrup. A concentrated syrup about two and one-half times the strength of ordinary maple syrup is now available which yields maximum flavor with minimum amount of sweetening. E.O.A.

348. **Sound Waves—A New Tool for Food Manufacturers.** L. A. Chambers. Food Ind. *10,* 3, p. 133, 1938.

A general discussion is presented of the theories regarding dispersion of particles by the sonic vibrator and the uses of the equipment in the milk and ice cream plant. E.O.A.

349. **Sodium Alginate as a Stabilizer.** Merrill J. Mack. Food Ind. *10,* 4, p. 195, 1938.

This article is a digest of the practical application of sodium alginate as a stabilizer in ice cream, market cream, sour cream, sweet cream, cheese spreads, chocolate milk and ices and sherbets. E.O.A.

Other abstracts of interest are numbers 315, 316, 317, 318, 321, 332, 334, 342, 343, 344, 345, 351, 355, 356, 359, 364, 368, 369, 370, and 371.

MILK

350. **Why Confusion in the Milk Industry?** F. J. Bahl, Mathews Frechtling Dairy Co., Cincinnati, Ohio. Milk Dealer *27,* 7, p. 40, 90, April, 1938.

The author points out that the fresh milk industry can no longer ignore canned milk as its competition. Canned, evaporated milk is here to stay, and the idea of pegging fluid milk prices according to the whim and fancies of any particular group is no longer possible.

The production of fluid milk does not vary importantly from the production of milk for evaporating purposes; and the idea of pegging fluid milk market continually and having its competitor, evaporated milk, buy on a formula basis is not logical. If it is logical, possible and practical to buy

milk for evaporating on a formula basis, a ratio can be established for fresh milk. It is time that this matter is presented to the government and other interested parties in a decisive way. No man can afford to ignore his competition any longer—either in the buying end or in the sales end.

A definite fixed ratio of one cent a quart more to a producer for producing fresh milk is suggested. C.J.B.

351. Cause of Black Spots in Milk Cans. (ANONYMOUS.) Milk Dealer *27*, 7, p. 42, April, 1938.

Report of an investigation showing that black spots in milk cans are frequently caused by leaving a stirrer of pure nickel in the can of milk.

The explanation given is that the black spots were caused by electrolytic action set up by the contact of two different metals; the lactic acid in the milk, slight as it was, setting up a condition similar to that found in a wet battery, the resulting electrolysis causing oxidation of the tin in the form of black spots, all with that characteristic jagged, uneven formation.

C.J.B.

352. Individual Tumblers of Milk for Restaurant Trade. (ANONYMOUS.) Milk Dealer *27*, 7, p. 43, April, 1938.

A description is given of how the Harding Restaurants in Chicago are serving pasteurized, homogenized milk in individual tumblers which the waiters open before the customers. C.J.B.

353. Improving the Quality of Milk. A. A. BORLAND, Penn. State College, State College, Pa. Milk Dealer *27*, p. 62, April, 1938.

A discussion on improving the quality of milk in which the author deals with flavor, cooling milk at the farm, cleaning utensils, color and vitamins in milk, inspection at the intake, and paying a bonus for premium milk.

C.J.B.

354. Daylight vs. Night Delivery. F. E. ROGERS, Thompson's Dairy, Washington, D. C. Milk Dealer *27*, 7, p. 56, April, 1938.

A discussion of the advantages, disadvantages, and consumer reaction to daylight delivery. The author sums the pros and cons of the subject by saying that daylight delivery has the preponderance of theoretical advantages. Practically, however, there are some very potent disadvantages to a widespread adoption of daylight service universally. C.J.B.

355. The Phosphatase Test as a Means of Determining Efficiency of Milk Pasteurization. HOMER L. SPENCER, City Health Dept., Tulsa. Milk Dealer *27*, 6, p. 66, March, 1938.

A description of the principles upon which the phosphatase test is based. Modifications of the original test are also given. The author concludes that it can be stated that although this test is probably not perfect in its present form, and that it may be modified from time to time as experience dictates and as needs for new application arise, the phosphatase test as devised by Kay and Graham offers the most accurate and sensitive means for determining the efficiency of pasteurization at present available. C.J.B.

356. Present Status of Phosphatase Test for Pasteurization. Walter Von Dohlen Tiedeman, State Dept. of Health, Albany, N. Y. Am. J. Pub. Health *28*, 3, p. 316, 1938.

The author believes that the phosphatase test for pasteurization has great practical value and reviews typical examples of violations that were found by the use of this test. Its great value to the milk control official is discussed by Paul F. Krueger, Director, Bureau of Dairy Products, Board of Health, Chicago, Illinois, and by Sol Pincus, Deputy Commissioner, Department of Health, New York, N. Y. M.W.Y.

357. Application of Scientific Control in the Bottling Industry. Max Levine, Dept. of Bact., Iowa State College, Ames, Iowa. Food Research *3*, 1 and 2, p. 141, Jan.–Feb., Mar.–Apr., 1938.

The problems of the bottling industry are discussed. The concentrations of sodium hydroxide in bottle washing with relation to thermal period to destroy bacteria are given. These data are applicable in the washing of milk bottles.

° F.	Per cent NaOH				
	1.0	1.5	2.0	2.5	3.0
	Time to kill (minutes)				
110	432.0	209.0	125.0	83.8	60.4
120	210.0	102.0	60.8	40.7	29.4
130	103.0	49.5	29.6	19.8	14.3
140	49.8	24.1	14.4	9.7	7.0
150	24.2	11.7	7.0	4.7	3.4
160	11.8	5.7	3.4	2.3	1.6
170	5.7	2.8	1.7	1.1	0.8
180	2.8	1.3	0.8	0.5	0.4

F.J.D.

358. Some Recent Advances in Dairy Technology. J. A. Tobey, American Inst. of Baking, New York. Food Research *3*, 1 and 2, p. 211, Jan.–Feb., Mar.–Apr., 1938.

The author discusses in a general non-technical manner the advances in

the dairy industry over the last 100 years, stressing particularly pasteurization, knowledge of nutrition, and irradiation. F.J.D.

359. **Researches on the Pasteurization of Milks for Human Consumption. I. Choice of a Culture Medium for the Counting of Microorganisms.** G. GUITTONNEAU, G. MOCQUOT, AND A. EYRARD, National Lab. of the Dairy Industry. Le Lait *18*, 173, p. 226, March, 1938.

It is stated as a general principle that a medium to be used in determining the bacterial content of milk should contain milk. Because of the opacity of media containing milk, the milk is subjected to a tryptic digestion for 3 days at 37°C (98.6°F.). Skimmilk treated in such a manner and diluted to 3 times its original volume constitutes a satisfactory media. The results obtained with pasteurized and raw milks were equivalent to those obtained when media containing small amounts of milk or lactose plus other sugars and peptones, *i.e.*, the media proposed by Bowers and Hucker and by Demeter. A.H.J.

360. **Address of the President.** R. C. FISHER, Intern. Assoc. Milk Dealers, Wellesley Farms Dairy, Wellesley Farms, Mass. Ann. Conv. Intern. Assoc. Milk Dealers, General Sessions, p. 11, 1937.

Progress of the organization and the milk industry during the past year is reviewed. Accomplishments of the following active committees are listed: Sanitary procedure, transportation, laboratory methods, simplified practice, accident prevention, public relations, and legislative. The service known as "The Balanced Job of Selling and Route Supervision" is explained. The aggressive policy of the Association with reference to public relations promoted under the auspices of the Milk Industry Foundation, is designed to pave the way for more effective sales promotion by the membership. National Milk Week has made a distinct contribution and offers possibilities for greater usefulness. E.F.G.

361. **Buying Plans. Ratio Between Cream Fat and Whole Milk Prices.** M. J. METZGER, Bowman Dairy Co., Chicago, Illinois. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 34, 1937.

The use of the method by which a premium over the evaporated milk formula price based upon the butter and cheese market now used in Chicago, is discussed. E.F.G.

362. **Uniformity of Dairy Score Card and Inspection.** WALTER D. TIEDEMAN, N. Y. State Dept. of Health, Albany, N. Y. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 40, 1937.

Overlapping milk sheds have created a situation where some dairy farms are under the inspection of as many as 9 inspectors and 8 different sets of regulations. Progress in elimination of conflicting regulations in New York State is reported; also some uniformity with New Jersey requirements. Further progress in uniformity must wait upon some interstate or government action. E.F.G.

363. Production Trends. JOHN B. SHEPARD, Sr. Agr. Statistician, U. S. Dept. of Agr., Washington, D. C. Ann. Conv. Intern. Assoc. Milk Dealers, Prod. Section, p. 47, 1937.

Over a 56 year period it appears that consumption has increased from around 750 pounds milk equivalent per person to 825 pounds or only about 10 per cent. Three things must be kept in mind. First, milk cows are beef and may be sold as beef. Second, milk cows are machines and may be slowed down or speeded up by price of feed. Third, many farmers will milk less when times are good and their time is worth more or more congenial labor is available. The fifteen year cattle cycle reached a low point in 1935. Possibly a larger proportion of the milk will, in the future, come from herds where machine methods can be used. E.F.G.

364. Plate Type Heat Exchangers. G. F. POPPENSIEK, Borden's Farm Prod., New York City. Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 63, 1937.

The development of plate heat exchangers used in Europe since 1923 and introduced into the U. S. in 1927 is traced. The writer reports the method of installation, operation and results from 32 of these heaters replacing various internal and external cooling units and heaters of various sorts. Favorable results are reported due to high regenerative efficiency, ease of cleaning, economy of floor space, etc. E.F.G.

365. Necessary Changes in the Average Plant to Comply with U. S. Public Health Service Standards Ordinance and Code. PAUL F. KRUEGER, Board of Health, Chicago, Illinois. Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 67, 1937.

A detailed discussion of the requirements of the ordinance with respect to buildings and floors, walls and ceilings, ventilation pipes and fittings, cleaning equipments and bottles and pasteurization. E.F.G.

366. Reports of Simplified Practice Committee. A. H. LUEDICKE, Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 75, 1937.

Two new solderless fittings are announced. The American Society for Testing Materials has organized Committee C–14 on Glass and Glass Prod-

ucts and glass bottle problems are being presented to this committee. A change in standards for glass milk bottles and a reduction of tolerances on stainless tubing are being proposed. E.F.G.

367. **Milk Machinery of the Future.** JOHN FORSLEW, Bowman Dairy Co., Chicago, Illinois. Ann. Conv. Intern. Assoc. Milk Dealers, Plant Section, p. 3, 1937.

The present trends in pasteurizing equipment suggest the possible more extensive use of short time high temperature pasteurization and eventually means other than heat for the destruction of bacteria. Bottle washers might combine the advantages of hydraulic and soaker types and incorporate better bottle cooling and automatic bottle feed. Bottle fillers, milk containers, fittings, can washers, can dumpers, milk cans, can washers and refrigeration are discussed from standpoint of probable future developments. E.F.G.

Other abstracts of interest are numbers 315, 316, 317, 318, 319, 326, 332, 336, 337, 338, 339, 340, 341, 342, 344, 345, 368, 369, 370, and 371.

MISCELLANEOUS

368. **What's New in Farm Science.** Part I. 54th Ann. Report of Director, year ending June 30, 1937. Agr. Exp. Sta., Univ. of Wisconsin, Madison, Wis., Bull. 439, Dec., 1937.

This bulletin briefly summarizes findings of work newly completed or in progress. The following sections are of interest to the dairy industry:

"Grass juice factor" is a new vitamin. G. O. Kohler, C. A. Elvehjem, and E. B. Hart, p. 2.

Progress in study of vitamin B. C. A. Elvehjem, A. Arnold, and E. B. Hart, p. 4.

A new dietary factor in the vitamin B complex. D. V. Frost, C. A. Elvehjem, p. 5.

Pigs and calves need fat along with skimmilk. E. J. Schautz, C. A. Elvehjem, and E. B. Hart, p. 10.

Nitrogen compounds in livestock feeding. E. B. Hart, H. J. Deobald, and G. Bohstedt, p. 11.

Tests on A. I. V. silage and milk. W. H. Peterson, G. Bohstedt, E. B. Hart, *et al.*, p. 14.

Who operates Wisconsin milk plants? A. W. Colebank, R. K. Frokker, and A. C. Hoffman, p. 35.

Accuracy of tuberculin testing. E. G. Hastings and J. R. McCarter, p. 53.

Spoilage of cheese brines. G. B. Landerkin and W. C. Frazier, p. 60.

Studies on Swiss cheese starter cultures. H. J. Pepler, P. R. Elliker, and W. C. Frazier, p. 61.

Vitamin C, oxidized flavor and the test for copper in milk. J. P. Turgeon, V. C. Stebnitz, and H. H. Sommer, p. 63.

Studies on lipase activity. K. G. Weckel, H. C. Jackson, and D. W. Jones, p. 65.

Microscopic examination of cheese. H. Templeton, D. K. Stewart, and H. H. Sommer, p. 66.

Test for extraneous matter in cheese. D. W. Spicer and W. V. Price, p. 67.

Acidity control in Brick cheese. D. W. Spicer and W. V. Price, p. 68.

Design of milk irradiating equipment. H. H. Beck, H. C. Jackson and K. G. Weckel, p. 70.

Abnormal milk and mastitis. E. G. Hastings, p. 75.

Bang's disease. M. R. Irwin, L. C. Ferguson, B. A. Beach, and G. C. Humphrey, p. 77. W.V.P.

369. The Use of Metals in the Dairy Industry. I. Aluminum. G. Genin, Paris, France. Le Lait *18*, 172, p. 113, Feb., 1938.

A review is given of the properties of aluminum as a material for the fabrication of dairy equipment and the behavior of aluminum in contact with dairy products. Among the phases of the subject discussed are: the historical development of metallic aluminum, aluminum alloys, methods of fabricating aluminum, commercial forms of aluminum, physical, chemical and mechanical properties of aluminum, superficial treatment of aluminum to allow painting, burnishing and polishing, the workability of aluminum, the corrosion of aluminum by milk, sterilizing solutions, brine and alkaline cleaning solutions. It is noted that many alkaline solutions are very corrosive to aluminum, but a solution containing 0.5 to 5.0 per cent sodium carbonate and 0.5 to 1.0 per cent of silicate of sodium has little corrosive effect. A.H.J.

370. The Cash Value of Safety. A. A. Nichoson, The Texas Co., New York City. Ann. Conv. Intern. Assoc. Milk Dealers, General Sessions, p. 34, 1937.

Accident costs are divisible two ways, the first a tangible cost, the second an intangible cost. This discussion concerns the former. Compensation insurance is based upon 60 per cent representing the loss and 40 per cent the expense. The 40 per cent breaks down as 17.5 per cent acquisition of new business, 2.5 per cent to taxes, 2 per cent to inspection and safety, 2.5 per cent to payroll audits, 8 per cent claim expense and 7.5 per cent home office expense. Manner of arriving at both "manual rate" and "countrywide rates" is explained. The "manual rate" can be reduced by practical and successful safety programs and results in savings to the industry.

Intangible costs have been rated on the basis of 4 to 1. That is, for each dollar paid in direct compensation, medical attention, etc., through personal injury to an employee, the organization loses an additional four dollars. Management has no greater opportunity of expressing the human

side of itself and its employees than through a safety program. People like to work for an organization that stands for a sound, Christian-like fundamental such as safety.

E.F.G.

PHYSIOLOGY

371. Concerning the Production of Alkaline Milk and of an Increase of the Iodine Index in the Fatty Matter in Milk Following Subcutaneous Injection of Dinitrophenol. E. Brouwer and J. Martin, Exp. Sta., Dept. of Phys., Hoorn, Holland. Le Lait *18*, 174, p. 337, April, 1938.

After the subcutaneous injection of dinitrophenol in the goat, there was observed a production of alkaline milk (pH 7.67–7.75), and the carbon dioxide content also showed a marked increase (up to 98 volume per cent). In the butterfat, there was also an increase in the iodine index of about 15 units. The diminution of the feed furnished the animals analogously caused an increase in the iodine index because under such conditions the reserve fat is utilized for the production of fat in the milk. The pH and acidity of the milk from the goats on the reduced ration however remained normal. It is probable that when the dinitrophenol is injected, it is absence of foodstuffs (because of feverish conditions of the goats and diminished appetite) that causes the change in iodine index. After each injection of a significant quantity, the milk assumes a yellow color due to the presence in the milk serum of dinitrophenol either as such or modified. The significance of the results are discussed from the standpoint of the physiology of the goat.

A.H.J.

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The American Dairy Science Association will pay 50c. for *No. 12, Volume XIX, 1936,* of THE JOURNAL OF DAIRY SCIENCE, if sent to:

Science Press Printing Company
Lancaster, Pennsylvania

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// JOURNAL OF DAIRY SCIENCE

VOLUME XXI SEPTEMBER, 1938 NUMBER 9

A STUDY OF THE RELATION OF THE FEED CONSUMED BY THE COW TO THE COMPOSITION OF MILK FAT AND THE PROPERTIES OF BUTTER*†

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The fact that cows can produce butterfat from rations low in ether extract has been shown by Jordan and Jenter (1), Hills (2), Lindsey (3) and Buschmann (4). Hansson and Olofsson (5) and Magi (6) have reported hard butter following winter feeding with hay and grain. Hansen and Stensberg (7) classified oats with the feeds producing normal butter and barley in the group producing hard butter. Many workers present data concerning the influence of feed consumed by the cow on the composition of butterfat. Few studies have been conducted to determine the relationships between observed changes in butterfat composition and its hardness due to feeding practice.

EXPERIMENTAL METHODS

Seven-day feeding periods were used except for part of the oil feeding trials in which six days were used. Although samples were taken at the end of each period, the roughage feeding was extended through two or more periods in order to allow time for the animals to reach equilibrium. Cows producing more than one pound of butterfat daily were used as experimental subjects. A basal mixture consisting of 70 parts barley and 30 parts bran, by weight, was used as concentrate unless substitutions or additions were made, as during the oats, corn, or oil feeding trials. Samples of butter and butter oil were prepared at the end of each feeding period as described by Coulter and Hill (8). Saponification value, iodine absorption value, Reichert-Meissl numbers, and melting points were made for butterfat samples. Hardness of butter and butterfat was determined according to the method described by Coulter and Hill (8). Butter hardness was not

* Received for publication March 16, 1938.

† This paper represents a portion of the thesis presented by O. J. Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy, University of Minnesota. Published with the approval of the Director as Paper No. 1600 Journal series, Minnesota Agricultural Experiment Station.

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determined for all samples since the correlation coefficient between hardness of butter and butterfat for 28 samples was + 0.905.

The effect of changing from the herd ration to the experimental rations consisting of barley, bran and hay (timothy or alfalfa)

Two groups of two cows each, consisting of one Jersey and one Holstein, were used in this experiment. The herd ration included a balanced grain ration, alfalfa hay and corn silage. Commercial casein was added to the timothy hay ration in sufficient quantities to properly balance the ration. A like amount of casein was fed to the group receiving alfalfa to equalize any effect the casein might exert. The experimental rations provided .23 pounds less fat daily per cow than the herd ration. As shown in Table 1,

TABLE 1

The effect of changing from the herd ration to the experimental rations on the fat constants and the hardness of butterfat

Period	Hay	Chemical constants			Physical constants	
		Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point °C.	Hardness grams
Group I 1	Herd[1]	236.1	29.34	30.32	32.55	1342
2	Timothy	231.8	31.71	27.11	32.90	1307
3	Timothy	231.4	31.43	26.52	33.15	1439
4	Timothy	234.6	28.15	29.48	32.90	1532
5	Timothy	235.2	25.48	28.84	33.90	1992
6	Timothy	236.4	25.01	30.04	34.00	2044
7	Timothy	235.9	25.05	29.37	34.25	2172
Difference Period 1 to 7 (19 days)		− 0.2	− 4.29	− .95	+ 1.70	+ 830
Group II 1	Herd[1]	233.5	32.40	27.94	32.05	1205
2	Alfalfa	233.8	29.40	28.43	33.45	1869
3	Alfalfa	234.0	28.79	28.64	33.10	1424
4	Alfalfa	232.2	30.00	26.47	34.20	1610
5	Alfalfa	233.1	26.20	25.57	34.85	2321
6	Alfalfa	232.7	27.32	26.90	34.82	2216
7	Alfalfa	234.1	27.70	26.87	34.00	1872
Difference Period 1 to 7		+ 0.6	− 4.70	− 1.07	+ 1.95	+ 667

[1] Fed on the regular herd grain ration, alfalfa hay, corn silage.

there was considerable change in chemical and physical constants in the butterfat from both groups of cows. In Group I there was a drop in iodine value of 4.29, in Reichert-Meissl number of 0.95, while melting point and hardness increased 1.70 degrees C. and 830 grams respectively. In Group II there was a decrease of 4.70 in iodine value, of 1.07 in Reichert-

Meissl number, and an increase of 1.95 degrees C. in melting point and 667 grams in hardness. Changes in saponification value were practically negligible. All the butters for period 5, 6, and 7 were scored "hard and brittle."

Influence of alfalfa hay, timothy hay, or combinations of these hays with beet pulp

Results for groups I and II, shown in Table 2, are a continuation of Table 1, except that they are averages for three periods. The groups were reversed in order to determine the response of each group to each roughage. Variances in the data are not sufficient to ascribe a specific effect to any one of the combinations fed. All butters during these periods were pronounced hard and dry by the judges.

Influence of heavy alfalfa feeding

In a further attempt to establish the effect of alfalfa on the chemical constants and hardness of butterfat, very high levels of alfalfa were fed to cow 419, a Holstein. This cow consumed 85 per cent of her total digestible nutrients in the form of alfalfa hay. Table 2 demonstrates a considerable

TABLE 2

The effect of feeding timothy hay, alfalfa hay, and beet pulp on the chemical and physical constants of butterfat (averages)

	Roughage	Chemical constants			Physical constants	
		Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point °C.	Hardness grams
Group I	Timothy hay	236.2	25.03	29.71	34.12	2108
	Alfalfa hay	234.2	26.30	28.41	34.30	2178
	Alfalfa hay and beet pulp	233.5	27.21	27.61	33.64	1943
Group II	Alfalfa hay	233.4	27.51	26.88	34.41	2044
	Timothy hay	233.6	27.93	26.71	34.02	1813
	Timothy hay and beet pulp	234.1	28.35	25.96	34.12	1829
Cow 419	Normal alfalfa	232.9	31.49	29.65	....	1253
	Heavy alfalfa[1]	230.8	35.85	28.01	....	1001
	Normal[2]	229.6	34.10	28.55	....	1231

[1] Average three periods.
[2] First period following heavy alfalfa.

change in butterfat constants during the heavy alfalfa feeding periods. The iodine value increased 4.36, the Reichert-Meissl number declined 1.64, with a decrease of hardness of the butterfat of 252 grams. The body of the butter was normal in all cases, although it was somewhat harder for the

basal periods. It is evident from Table 2 that the alfalfa hay in this experiment was responsible for increasing the iodine value and decreasing the hardness of butterfat more than the alfalfa-barley-bran ration. When the alfalfa was reduced to normal amounts in the after period the hardness of the fat increased without a corresponding decrease in the iodine value. Richardson and Abbott (9) show similar increases in iodine value during alfalfa feeding, but in spite of these changes, report a "sticky" crumbly butter unless special churning procedure is followed.

The effect of including oats and corn in the ration on the chemical constants and physical properties of butter and butterfat

The preceding data, representing the roughage feeding experiments, showed that a hard butter of low iodine value was produced except when alfalfa was fed. The following experiments were planned in an attempt to ascertain the influence of substituting cereals higher in fat for the barley part of the ration. In all cases basal ration refers to the mixture, 70 parts barley and 30 parts bran, fed with alfalfa hay. Oats or corn replaced the barley in the basal ration during these experiments. In each case the cereal supplied 40–50 per cent of the total digestible nutrients. The experiment for cow 419 had to be altered somewhat because the oats were of such low grade, containing but 2.51 per cent ether extract compared to 3.73 per cent for the lot fed to the groups. Corn was fed with the oats to avoid

TABLE 3

The effect of substituting oats or corn for barley on the chemical constants and hardness of butterfat (average)

	Ration	Chemical constants			Physical constants	
		Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point °C.	Hardness grams
Group I	Basal[1]	231.7	28.31	27.47	34.63	1884
	Oats	228.7	35.51	28.81	33.12	1140
	Difference	−3.0	+7.20	+1.34	−1.51	−744
	Corn	229.4	35.15	27.74	32.70	1120
	Difference	−2.3	+6.84	−0.27	−1.93	−764
Group II	Basal[1]	231.9	30.06	25.80	33.75	1757
	Oats	228.4	34.56	25.47	32.97	1372
	Difference	−3.5	+4.50	−0.33	−0.78	−385
	Corn	227.4	35.95	23.79	32.15	1093
	Difference	−4.5	+5.89	−2.01	−1.60	−664
Cow 419	Basal[1]	233.1	34.35	29.84	....	996
	Oats and corn	230.5	36.37	29.30	....	926
	Difference	−2.6	+2.02	−0.54	....	−70

[1] Barley, bran and alfalfa hay.

underfeeding as well as to increase the fat content of the ration. The data presented in Table 3 show that during the oat feeding period in Group I the saponification value, melting point, and hardness decreased 3.0, 1.51° C. and 744 grams respectively. The iodine value increased 7.20 and the Reichert-Meissl number 1.34. Corn brought about very similar changes except for the Reichert-Meissl which decreased slightly. Group II gave results in the same direction, but in less degree except for the Reichert-Meissl which decreased, especially during the corn feeding. Results for cow 419 show an increase of only 2.02 for the iodine value with no appreciable change in hardness. The butters produced during these periods were graded normal in body, as contrasted to the harder butters produced during the basal periods.

The effect of feeding fats and oils on the chemical constants and physical properties of butter and butterfat

The literature reveals a close relationship between the quantity of fat in the ration and the influence on the properties of butterfat. It was evident in the experiments reported in Table 4 that the oil in the corn and oats was responsible for the effects observed. Further study of feeding fats and oils possessing widely different characteristics was undertaken. The oils and fats studied were corn oil, linseed oil, cottonseed oil, tallow, butterfat and coconut oil. The iodine values of the several fats were as

TABLE 4

The effect of feeding corn oil on the chemical and physical constants of butterfat

Group	Ration	Amount oil fed lbs.	Chemical constants			Physical constants	
			Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point °C.	Hardness grams
II	Barley, alfalfa,	0.0	228.7	33.19	24.40	....	1382
	bran	0.3	226.4	37.43	25.12	....	1118
		Difference	−2.3	+4.24	+0.72	....	−264
III	Herd ration with corn	0.0	236.0	30.50	31.15	32.10	1347
	silage and alfalfa	1.0	228.3	41.00	30.36	32.25	976
		Difference	−7.7	+10.50	−0.79	+0.15	−371
IV	Same as	0.0	234.2	30.28	30.60	32.55	1551
	Group III	1.0	229.0	40.20	31.93	32.60	1127
		Difference	−5.2	+9.92	+1.33	+0.05	−424
Cow 151	Barley, bran,	0.0	232.1	32.50	29.00	....	1396
	alfalfa	0.8	231.3	35.78	29.00	....	1115
		Difference	−0.8	+3.28	0.00	....	−281

follows: for coconut oil, 7.94; tallow, 37.48; cottonseed oil, 108.55; corn oil, 123.14; and linseed oil, 169.04. The feeding conditions were standardized so that the effect of feeding the oil could be compared with a preliminary and an after period in which no extra oil or fat was fed.

During these oil feeding periods, Groups I and II, and cows 151, a Jersey, and 419 were fed the basal grain ration and alfalfa hay. Groups III and IV, composed of three cows each, a Guernsey, a Holstein, and a Jersey, received regular Experiment Station herd ration, with corn silage and alfalfa hay, according to milk production and body weight. Groups V and VI, composed of two cows each, a Guernsey and a Jersey, were fed the Experiment Station ration and alfalfa hay according to weight and milk production. These diverse feeding practices offered an opportunity to study the effect of fat feeding under varied conditions. The fat or oil was added to the regular ration, thereby increasing the total digestible nutrients.

a. *Influence of feeding a low level of corn oil*—This experiment was designated to determine if corn oil when fed in addition to the basal ration would produce results similar to those secured when corn was fed. The digestible fat in the corn ration exceeded that in the basal ration by 0.28 pounds daily for the Jersey cows, and 0.31 pounds for the Holsteins. These amounts of oil were added to the basal ration of Group II. Table 4 shows the results secured. The iodine value and Reichert-Meissl number increased 4.24 and 0.72 respectively, whereas, the saponification value decreased 2.3 and the hardness declined 264 grams. Except for the Reichert-Meissl these alterations from the basal periods are in the same direction as those shown in Table 3 for oats and corn feeding. The higher iodine value obtained on the basal ration in Table 4, as compared with Table 3, may be attributed to advance in lactation. The body of the butters was normal in all cases.

b. *Influence of feeding corn oil at higher levels*—Table 4 also shows results following the feeding of one pound of corn oil to Group III and IV and 0.8 pound of corn oil to cow 151. The saponification value declined 0.8 for cow 151 and 7.7 for Group III. The iodine value increased 3.28 for cow 151 and 10.50 for Group III. Changes in Reichert-Meissl number were not consistent and in melting point were insignificant. An unmistakable decrease in hardness of the fat resulted, this decrease being 281 grams for cow 151, 424 grams for Group IV, and 371 grams for Group III.

Thiocyanogen values were run on the butterfat from cow 151 in the basal and corn oil feeding periods using the method of Kaufman (10) as modified by Zeleny and Bailey (11). Using the difference between the iodine value and the thiocyanogen value as a measure of fatty acids less saturated than oleic it was found that the difference for the corn oil feeding period was only 0.38 greater than for the mean difference of the two basal periods, being 3.02 for the latter and 3.40 for the former.

c. *Influence of feeding linseed oil*—Linseed oil was fed in quantities from 0.8 to 1.25 pounds daily. Table 5 gives the results. Group V showed the greatest changes in iodine value, but the decrease in hardness was

TABLE 5

The effect of feeding linseed oil and cottonseed oil on the chemical constants and hardness of butterfat

Group	Amount of oil fed lbs.	Chemical constants: Saponification value	Iodine value, per cent	Reichert-Meissl number	Hardness, grams
	Linseed oil				
Cow 419	0.0	231.9	34.00	28.81	1138
	0.9	227.2	42.21	27.63	922
Difference		−4.7	+8.21	−0.18	−216
Cow 151	0.0	233.7	29.29	29.20	1885
	0.8	229.7	41.17	30.11	1047
Difference		−4.0	+11.88	+0.91	−838
V	0.0	227.7	38.17	26.33	1126
	1.25	219.1	54.28	24.34	771
Difference		−8.6	+16.11	−1.99	−355
VI	0.0	226.8	42.45	25.73	725
	1.25	218.6	50.85	22.87	685
Difference		−8.2	+8.40	−2.92	−40
	Cottonseed oil				
III	0.0	236.0	30.47	32.45	1502
	1.0	228.9	38.35	33.20	1199
Difference		−7.1	+7.88	−0.25	−303
IV	0.0	235.1	30.22	30.84	1502
	1.0	229.8	37.60	30.76	1677
Difference		−5.3	+7.38	−0.12	+175
Cow 151	0.0	231.5	33.68	28.74	1330
	0.8	231.8	33.12	28.43	1273
Difference		+0.3	−0.56	−0.31	−57

about midway between the greatest and the least observed in the trial. The increase in iodine value was least for Group VI, although the same amount of oil was fed as in the case of Group V. Hardness for Group VI declined only 40 grams; it is evident that the decline in hardness which might have been expected as the result of the higher iodine value was very nearly offset by the decline in Reichert-Meissl number. Cow 151 showed an increase of 11.88 in iodine value of her butterfat and the hardness dropped 838 grams, whereas cow 419 showed an increase of 8.21 in iodine value accompanied by a decrease of 216 grams in hardness. In the one case (cow 151) both the unsaturated and the volatile fatty acids increased, while in the other the increase in unsaturation was offset, in part, by a decrease in volatile fatty acids. The saponification values in general followed the changes in Reichert-Meissl numbers, as would be expected.

The mean difference between iodine and thiocyanogen values for the basal ration periods preceding and following the linseed oil feeding was 3.53. In the oil feeding period it was 4.98, showing that linseed oil causes a definite rise in the fatty acids less saturated than oleic acid in butterfat.

d. *Influence of feeding cottenseed oil*—Table 5 also gives the effects of feeding cottenseed oil. Comparable results were obtained for Groups III and IV except for hardness, which increased 175 grams for Group IV and decreased 303 grams for Group III. Cow 151 did not show changes in fat constants of as great a magnitude as either Group III or IV, her butterfat remaining very constant in hardness. It is evident from the results for Groups III and IV that the effect of cottonseed oil feeding on the hardness of the butterfat cannot be predicted from the change in iodine value. When cow 151 was fed cottonseed oil, the butter had a gummy body that was unmistakably different from that produced during corn oil or linseed oil feeding.

The cottonseed oil had very little effect in increasing the fatty acids less saturated than oleic acid, judging from the difference between the iodine and thiocyanogen values of the butterfat of cow 151. In the period preceding the oil feeding the difference was 3.05 and in the oil feeding period it was 3.15.

e. *Influence of feeding tallow*—The results of adding one pound of tallow to the basal ration are given in Table 6. It is evident that the tallow depressed the saponification value, with but little change in iodine value or Reichert-Meissl number. This points to an increase in the non-volatile saturated fatty acids since the saponification value decreased without an alteration in the iodine value. The melting point and hardness were increased, but not to the same degree in each case.

f. *Influence of feeding butterfat*—The oils fed in the preceding experiments were of a very different composition than butterfat. These oils had a low saponification value, high iodine value, and no volatile fatty acids. Tallow did not have such a high iodine value, but the saponification value was low. Butterfat was fed in an attempt to determine the effect of feeding a fat containing all the fatty acids of the resulting product.

It will be observed in Table 6 that feeding rendered butterfat brought about some very significant changes in the properties of the butterfat produced. The iodine value decreased 1.69 for Group IV and increased 0.46 for Group III. The average decline in saponification value was 3.0 with a decrease in Reichert-Meissl number of 0.62. Melting point and hardness were augmented most. These changes are much greater than those observed for tallow feeding. The small drop in saponification value indicates an increase in saturated acids, since the iodine value did not increase appreciably. The changes in fat constants fail to explain the differences observed in melting point or hardness of the butterfats obtained.

TABLE 6

The effect of feeding tallow, butterfat and coconut fat on the chemical and physical constants of butterfat

Group	Amount fat fed lbs.	Chemical constants			Physical constants	
		Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point ° C.	Hardness grams
	Tallow					
III	0.0	237.5	31.44	29.35	33.50	1430
	1.0	229.8	32.61	29.59	34.35	1651
Difference		−7.7	+1.17	+0.24	+0.85	+221
IV	0.0	235.2	30.60	30.60	33.00	1730
	1.0	230.2	30.71	30.71	34.35	1745
Difference		−5.0	+0.11	+0.11	+1.35	+15
	Butterfat					
III	0.0	233.4	28.90	28.83	33.50	1815
	1.0	230.0	29.36	28.63	35.25	2246
Difference		−3.4	+0.46	+0.20	+1.75	+431
IV	0.0	234.0	29.47	30.36	32.95	1675
	1.0	231.5	27.78	29.15	35.45	2389
Difference		−2.5	−1.69	−1.21	+2.50	+714
	Coconut fat					
151	0.0	233.4	29.25	29.00		1791
	0.8	238.4	24.65	29.22		2210
Difference		+5.0	−4.60	+0.22		+419
419	0.0	232.8	32.45	29.37		1212
	1.0	235.9	28.96	28.96		1743
Difference		+3.1	−3.49	−0.41		+531

The body of these butters was firm but not hard or brittle.

g. *Influence of feeding coconut fat*—The preceding experiments have shown the effects on the fat constants produced by feeding oils of fats having a wide range of iodine values. It was therefore considered important to include in further experiments a highly saturated fat. Coconut fat contains only 6–10 per cent oleic acid and approximately one per cent of linoleic acid. It also has a higher saponification value than the oils or fats fed in the foregoing experiments. The data presented in Table 6 give the individual results following the feeding of coconut fat. The iodine value was depressed 4.6 for cow 151 and 3.49 for cow 419, the saponification value increased 5.0 for cow 151 and 3.1 for cow 419, and the hardness of the butterfat increased 419 grams for cow 151 and 531 grams for cow 419. These butters were very hard and brittle, especially that from cow 151, which was somewhat crumbly. The structure of the butterfat in these butters appeared to be almost crystalline when they broke at temperatures of 54 degrees F.

Thiocyanogen values were also determined in connection with the coconut fat feeding. The average differences between iodine values and thio-

cyanogen values for the two cows were as follows: For the basal periods, 2.87; for the coconut fat feeding, 2.41. The results indicate some decrease in acids less saturated than oleic due to feeding coconut fat.

h. *Influence of feeding cane sugar*—In the experiments so far reported the effects of various oils and fats on the composition and properties of butterfat were studied through the addition of the oils and fats to the basal ration. This also involved an increase in digestible nutrients of the ration in a special form. In order to determine the effects of the addition of the same amount of nutrients in other forms, an experiment was conducted in which cane sugar was added to the basal ration. It was hoped that this experiment would also assist in interpreting the data reported in the literature relative to the relation of easily fermented carbohydrates in food to the formation of the volatile fatty acids in butterfat. The results in Table 7 show an average increase in saponification value of 2.0, in Reichert-Meissl number of 0.92, and in hardness 146 grams. The iodine value changed but slightly, decreasing 0.64. The increase in hardness corresponds with the slight decrease in iodine value.

TABLE 7

The effect of feeding cane sugar on the chemical constants and hardness of butterfat

	Amount fed lbs.	Chemical constants			Physical constants	
		Saponification value	Iodine value per cent	Reichert-Meissl number	Melting point ° C.	Hardness grams
Group III	0.00	233.4	28.03	28.33	33.20	1611
	2.25	237.0	27.10	30.66	33.10	1735
	Difference	+3.6	−0.93	+2.13	−0.10	+124
Group IV	0.00	236.2	27.87	30.99	33.10	1798
	2.25	236.6	27.42	30.70	33.40	1947
	Difference	+0.4	−0.35	−0.29	+0.30	+149

The Effect of Including Pasture in the Ration

Analyses were made of the butterfat from the University herd previous to turning onto grass and for two weekly periods thereafter. This change is shown in Table 8. The effect was a decrease in saponification and Reichert-Meissl numbers of 2.2 and 0.43 respectively with an increase in iodine value of 3.17. No difference was found in the hardness of the butterfat.

Two cows, 151 and 419, were removed from pasture during the summer in order to throw further light on the effect of pasture on the character of the butterfat. Table 8 shows the results from these two cows. The average effects were as follows: the saponification value increased 2.15, the Reichert-Meissl number decreased 0.20, and the hardness increased 372 with a decrease in iodine value of 3.77. The changes observed in this

TABLE 8

The effect of including pasture in the ration on the chemical constants and hardness of butterfat

Sample	Ration	Chemical constants			Hardness grams
		Saponification value	Iodine value per cent	Reichert-Meissl number	
Station herd	Station ration	229.7	35.25	29.08	952
	Pasture and herd ration	226.5	38.42	28.65	951
	Difference	− 2.2	+ 3.17	− 0.43	− 1
419	Pasture and herd ration	224.3	43.18	27.40	606
	Basal	226.6	40.18	27.85	657
	Difference	+ 2.3	− 3.00	+ 0.45	+ 51
151	Pasture and herd ration	231.8	34.65	29.06	990
	Basal	233.8	30.11	28.30	1684
	Difference	+ 2.0	− 4.55	− 0.86	+ 694

experiment, which may be attributed to grass, are much less than those reported in the literature.

The Composition and Properties of Six Commercial Samples of Butter

The experiments recorded in the preceding pages have shown that certain factors produced butterfat of a low iodine value exhibiting hard characteristics. It seemed of interest to compare these results with those from samples of butter obtained from regions where similar body defects have been reported. Normal samples were also obtained for comparison. Five of these samples were made available through the courtesy of Dr. G. H. Wilster of the Oregon Agricultural Experiment Station, the other by Mr. Al Forte from the Mandan Creamery, North Dakota. The chemical constants and history of the samples are given in Table 9.

The data reveal considerable difference in the hardness of the butterfats with only a slight range in the iodine value. The hard butters (1, 2, and 5) were from sections in which Jerseys are the predominating breed and alfalfa hay is fed in large quantities. The grain ration is made up largely of barley and millrun, a small quantity of linseed meal being included in the concentrate for part of the herds. Sample 3 apparently was influenced by the fall pasture; in addition, the mixed grains contained a considerable quantity of oats. It is evident from the hardness studies and the comments on the butters that those samples associated with alfalfa feeding are most abnormal. However, barley was included in the grain ration for the herds from which the samples were produced. Furthermore, Jerseys were the predominating breed. Breed exerts a definite influence on hardness of butter as shown by Coulter and Hill (8).

TABLE 9

The chemical constants, hardness, body criticisms and history of six commercial samples of butter

Sample number	Body criticism	Chemical constants			Hardness grams
		Saponification value	Iodine value per cent	Reichert-Meissl number	
1	Slightly crumbly and brittle	231.5	32.48	26.93	1951
2	Sticky	230.1	31.10	26.44	1860
3	Normal	226.9	33.43	27.44	1261
4	Normal but firm	230.3	31.89	29.95	1471
5	Slightly crumbly	231.8	30.69	27.33	2214
6	Normal but firm	228.9	32.58	27.38	1423

History of samples

Sample number	Place made	Breed of cows		Feeds
		Predominating	Others	
1	Klamath County, Oregon	Jersey	Red cows	Alfalfa hay, cull potatoes, barley, millrun, and linseed meal.
2	La Grande, Ore.	Jersey	Shorthorns	Alfalfa, corn, silage, barley, millrun, and linseed meal.
3	Gray's River, Washington	Jersey and Guernsey		Grass hay, mixed grain, fall pasture.
4	Corvallis, Ore.	Jersey		Oats and vetch hay, clover hay, mixed silage, kale, millrun chief concentrate.
5	Redmond, Ore.	Jersey		Alfalfa hay, barley, millrun,[1] and linseed meal.
6	Mandan, N. Dak.	Mixed cows all breeds		Mixed hay (chiefly prairie) and corn.

[1] Millrun is made up of the by-products of flour manufacture consisting of bran, middlings, and in some cases ground screenings.

DISCUSSION

Changing from the Experiment Station herd ration, consisting of the herd grain ration, alfalfa hay, and corn silage, to the experimental ration and timothy hay or alfalfa hay, exerted a very profound influence on the characteristics of the butterfat. The averages of the effects were: The iodine value declined 4.49, the Reichert-Meissl number declined 1.01, but the melting point and hardness increased 1.82 degrees C. and 748 grams, respectively. The only change of any significance in the nutrients supplied was a decrease of 0.198 pounds of fat daily. This decrease in amount of fat in the ration was apparently responsible for producing the hard butters observed in both groups.

The fat constants, hardness, and melting point of butter obtained when using timothy hay, alfalfa hay, and beet pulp were not significantly different. It is evident that the fat from each of these feeds exerts an equal effect on the composition of butterfat when fed in combination with a low fat grain mixture. These feeds produced a hard butter not conforming to the characteristics usually associated with superior butter.

Increasing the alfalfa in the ration to such an extent that 85 per cent of the total digestible nutrients were supplied from it brought about rather marked changes in the butterfat of one Holstein cow used in the test. The chief effect was an increase of 4.36 in the iodine value and a decrease of 252 grams in the hardness of the butterfat. The Reichert-Meissl value decreased 1.64. These changes in iodine value conform closely to those reported by Richardson and Abbot (9) for butterfat from cows restricted to alfalfa feeding. However, these workers report a "sticky" body for these butters which was not found in the experiment reported here.

Including pasture in the herd ration resulted in an increase of 3.17 in the iodine value without any effect on the hardness of the butterfat. With two individual cows the reverse procedure, *i.e.*, removal of the cows from pasture to the basal ration, decreased the iodine value and increased the hardness of the butterfat, especially when the decrease in iodine value was accompanied by a decrease in Reichert-Meissl number.

The results with the cereals demonstrate that the effect of corn, oats, and barley are due to the character and amount of the fat they contain. Table 3 shows conclusively that barley feeding resulted in the production of a hard butter, whereas corn and oats produce butters with a desirable body and firmness. Corn oil, when added to the barley-bran ration in quantities equivalent to the difference between the oil content of the barley plus bran and the corn plus bran rations, brought about results very similar to those produced when corn was fed. These experiments were undoubtedly influenced somewhat by outside factors not under control; however, the results are sufficiently consistent to justify the above conclusion.

The literature appears to show that the iodine value of the oil in a feed or ration will be directly responsible for the hardness of butterfat. This apparently holds true insofar as certain oils are concerned, but does not hold true in all cases. It is true that the iodine value o[illegible] in differencefat
largely determines the iodine value of the butterfat. F[illegible]
seed oil increased the iodine value most with corn oil an His help and
following rather closely. Both tallow and butterfat bei[illegible] is gratefully
unsaturated had but slight influence on the iodine value
Coconut oil being very highly saturated produced a b[illegible]
lower iodine value and higher saponification value than New York Experi-
tion. Considering that the above oils were added to a r[illegible]
plying sufficient total digestible nutrients to satisfy th[illegible]

is very evident that these oils modified the fat forming processes already going on in the animal body.

However, the oils and fats in feed do not influence the hardness of butterfat to the same degree that they affect the iodine value. Corn oil influenced the hardness equally as much as the linseed oil. Examination of the butter produced during the feeding of linseed oil revealed a somewhat firmer body than that produced during corn oil feeding. The butter from corn oil feeding tended to be somewhat softer and mushy. Cottonseed oil, on the other hand, increased the iodine value but did not appreciably decrease the hardness except with one group of cows; furthermore, the body of the butter was gummy and sticky and did not melt easily when tasted. Tallow did not appreciably alter the composition of the fat or the hardness of the butterfat. Butterfat feeding likewise did not alter the iodine value or Reichert-Meissl number to any marked extent; however, it did increase very markedly the melting point and the hardness of the fat. The butters in these cases were tough but not brittle, indicating further change in the structure of the triglycerides.

Recent experiments by Schoenheimer (12) may explain the failure of the volatile fatty acids fed in the butterfat feeding periods to appear in the milk fat. Using deutero-fatty acids to trace their fate after ingestion, he reports that butyric and caproic acids are completely oxidized (by mice) and only higher fat acids are deposited.

Coconut fat unmistakably decreased the iodine value of the butterfat, increased the saponification value, and markedly increased the hardness of the butterfat. The change observed was dependent on the initial properties of the butterfat; since cow 419 was producing a relatively normal fat on the basal ration, the addition of coconut fat did not produce a butter exhibiting a body of a firmer character than might be expected from feeding a low fat diet. In contrast, cow 151, already producing a relatively hard butter, produced a very hard, brittle butter, approaching crumbliness, following the coconut oil feeding. This butter was nearly the hardest produced during the experiment. The fats had iodine values very similar to those observed in the roughage feeding tests; however, the other characteristics of the fat were considerably different.

The feeding of sugar had no discernible effect on the fat constants. The hardness was increased slightly but not sufficiently to be of any real importance, thus further supporting the assumption that the fat is a more important factor influencing butterfat composition than the energy supplied.

The discussion concerning the hardness of butterfat and the iodine value tends to emphasize certain specific effects for feeds other than those exerted on the iodine value. Generally speaking it is possible to deduce from Coulter and Hill (8) that there is a highly significant relationship between iodine value and hardness of butterfat. The index of correlation was 0.85 with less than one chance in 100 that this value could come from chance.

Cottonseed oil feeding gave hardness values entirely out of line with the iodine value, especially in the group feeding tests.

Hilditch and Sleightholme (13) and Banks and Hilditch (14) have discussed the importance of the saturated triglycerides in feed imparting to animal fats their characteristic properties such as melting point and consistence. In all the samples reported by these workers the fully saturated portions of the butterfat were very similar in composition. Following the feeding of oils the changes of most importance occurred in the percentage of non-fully-saturated glycerides. When considering these findings in relation to the results obtained in the present study it appears that an increase in non-fully-saturated glycerides, in addition to an increase in the quantity of unsaturated acids present in the portion previously non-fully-saturated, no doubt played an important part in the changes observed in hardness. The decrease in the slope of the curve shown by Coulter and Hill (8) may be explained by a more complete unsaturation of the non-fully-saturated triglycerides. In this case the fully-saturated glycerides could exert a more constant effect in retaining the consistency of the butterfat.

CONCLUSIONS

1. When barley constitutes 35–50 per cent of the digestible nutrients of a low fat ration containing alfalfa or timothy hay, fed to dairy cows, hard butterfat with a low iodine value is produced.
2. When oats or corn are substituted for 35–50 per cent of the digestible nutrients of a low fat ration, containing alfalfa hay, fed to dairy cows, the physical characteristics of the butter produced are satisfactory from the market standpoint, and the chemical characteristics of the fat are more or less specific for the type of ration fed.
3. When alfalfa hay, timothy hay or beet pulp are fed with a low fat grain ration to dairy cows, they exert a similar effect on the composition and physical properties of butterfat.
4. When oils or fats are fed to dairy cows the resulting butterfat assumes some of the chemical characteristics of the fat or oil fed.
5. When 0.6 pounds or more of linseed oil is fed daily to dairy cows the butterfat produced shows a significant increase in the content of fatty acids less saturated than oleic acid, as judged by the increase in difference between the iodine and thiocyanogen values.

The late Doctor C. H. Eckles suggested this study. His help and criticism in planning and carrying out the investigation is gratefully acknowledged.

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SOME CAUSES FOR THE DETERIORATION IN 10 DAYS AT 15.5° C. OF SALTED BUTTER MADE FROM SOUR CREAM[1]

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Much research work (4, 5, 9, 10, 11) has been done on the problem of keeping quality of butter in commercial cold storage; however, less consideration (6, 13) has been given to keeping quality of the butter while it is in the various trade channels and in the home of the consumer where it may be held for periods of time at temperatures far too high for satisfactory butter storage. During this time, when at relatively high temperatures, some butter preserves its flavor while in other butter the flavor deteriorates. In order to determine some of the causes of these flavor changes, this study was undertaken.

An explanation of the possible causes of deterioration in flavor have been bacteria, yeasts, molds, the inherent enzymes of the milk, and chemical action taking place within the constituents of butter.

For this study a number of samples of typical centralizer butter made in Indiana and neighboring states were available. In addition to the microbiological analyses, each sample was scored when obtained and given a keeping quality test which consisted of holding the butter for 10 days at 15.5° C. and then rescored. The scoring was done by Dr. B. E. Horrall and the scores were then checked by the authors individually and average scores recorded. The butter was examined bacteriologically, after incubation, in an effort to determine some of the factors that were involved in its deterioration.

THE KEEPING QUALITY OF SALTED BUTTER MADE FROM SOUR CREAM

In this study 504 samples were examined. The butter was manufactured in a nine-month period starting September, 1936 and the number of samples received each month was approximately the same and from the same creameries. The drop in score in samples of butter during the 10 day holding period at 15.5° C. is shown in Table 1.

It may be assumed that butter which does not decrease in score more than one point will stand up under the conditions of refrigeration used by distributors and consumers. As shown in Table 1, 25 per cent of the samples

Received for publication October 15, 1937.

* Industrial Fellowship of the Dairy and Ice Cream Machinery and Supplies Association.

1 The data in this paper was taken in part from a thesis presented by J. C. Flake in partial fulfillment of the requirement for the Master of Science degree, and is published with the approval of the Director of the Agricultural Experiment Station.

TABLE 1

The keeping quality of salted butter made from sour cream as indicated by change in score after 10 days at 15.5° C.

	Drop in score in points				
	0	0.5–1	1.5–2	2.5–3	3.5 or more
Number of Samples	163	214	73	39	15
Percentage of Samples	32	42	14	8	3

decreased in score more than one point and 11 per cent decreased 2.5 points or more in score.

TABLE 2

The drop in score of butter after holding for 10 days at 15.5° C. according to the original score of the same butter

	Original Score			
	91 or more	90.5–90	89.5–89	88.5 or less
Number of Samples	31	157	255	63
Average Drop in Score	2.0	0.86	0.60	0.68
Per Cent not Dropping in Score	0	27	38	37

In Table 2 the data are presented to show the influence of the original score of the butter upon its keeping quality as measured by the method used. The bulk of the samples examined had original scores between 90.5 and 89. However, in the butter scoring 91 or more, the deterioration was so consistent that the results are significant in that no sample was found which did not decrease in score and this average decrease was 2 points. The decrease in score of the butter scoring 90.5 to 90 was 0.86 points and 27 per

TABLE 3

Relation of the month of manufacture to the drop in score of butter

Month 1936–37	No. of Samples	0–5	Percentage of samples decreasing in score	
			1–1.5 points	2 or more points
September	54	30	48	22
October	59	27	54	19
November	61	44	41	15
December	60	40	42	18
January	57	30	47	23
February	53	37	47	16
March	50	48	38	14
April	61	69	23	8
May	52	47	38	15

cent of the samples retained their original score. Butter which scored below 88.5 showed approximately the same drop in score and with the same percentage of samples decreasing in score as did butter scoring 89.5 to 89.

In Table 3 are presented data showing the relation of the month in which the butter was manufactured to decrease in score in 10 days at 15.5° C.

The butter manufactured during the colder months of the year showed no significantly better keeping quality than butter made in the fall or spring. In January, butter of the poorest keeping quality was manufactured, while in April the butter of the best keeping quality was manufactured of the months studied. However, in May, the keeping quality decreased approaching the median for the period.

THE INFLUENCE OF THE MICROBIOLOGICAL CONTENT OF THE BUTTER UPON ITS KEEPING QUALITY

In that butter consists of 80 per cent fat, which is an inert material to many micro-organisms, it presents a microbiological problem entirely different from that of other dairy products. This is further emphasized by the fact that butter is an emulsion of water in fat, while in milk and most other dairy products the water is the continuous phase.

It was deemed advisable to study the general microscopic picture of the butter flora to determine whether or not micro-organisms were the cause of the decrease in score. This was done by preparing a sample of centrifugally separated serum using the method developed by Hammer and Nelson (3) and staining with the technique of Newman (7).

The examination of 103 samples of butter which had dropped from zero to four points in score during the holding period revealed that there was a limited relation between the microscopic picture and the decrease in score. In general, it was found that large numbers of rod-shaped organisms were found in butter having poor keeping quality. These results are similar to those reported by Nelson (6). No relation was found to exist between the decrease in score and the numbers or arrangement of cocci contained in the smear of butter serum.

Previous workers (2, 11, 12) have endeavored to determine the influence of proteolytic and lipolytic organisms upon the keeping quality of butter by enumerating the numbers of these organisms in freshly manufactured butter. Since there are a number of factors other than time and temperature of incubation which affect the growth of micro-organisms in butter, a study was made to determine the numbers of proteolytic organisms in the butter at the end of the holding period of ten days at 15.5° C.

At the conclusion of the holding period, the samples of butter were plated on tryptone-skim milk agar for the purpose of detecting proteolytic organisms. The composition of the medium used, as modified from the casein containing medium suggested by the American Dairy Science Association

Sub-Committee on Microbiological Methods of Examining Butter (8), was as follows: 0.5 per cent tryptone, Difco; 1.5 per cent agar agar; 5.0 per cent skim milk, added just before pouring plates. The final pH was 6.8 to 7.2. Incubation was for five days at 21° C. Proteolytic colonies were judged by their appearance and when in doubt the plates were flooded with five per cent tannic acid.

The results from 101 samples selected at random from the 504 samples are shown in Table 4, with the counts tabulated according to drop in score of the butter. The samples which dropped less than one and one-half points in score had comparatively low logarithmic average proteolytic counts. The averages for the samples which dropped two to two and one-half points are

TABLE 4

Relation of proteolytic bacterial count to drop in score of butter held for ten days at 15.5° F.

	Drop in Score in Points							
	0	1	1.5	2	2.5	3	3.5	4 or more
Number of Samples	22	9	18	22	8	12	4	6
Logarithmic Average of Proteolytic Counts	9,250	2,350	5,000	31,000	23,000	7,500	4,000	32,000
Proteolytic Bacterial Counts of 100,000 or more—per cent	4.5	11.0	5.6	36.4	50.0	16.7	25.0	50.0

much higher, as is true for those which dropped four or more points. However, the samples which dropped three to three and one-half points show low proteolytic counts, being similar to the samples which had only a slight drop in score. The reason for these low counts is difficult to explain, especially in view of the limited number of samples. The organisms may have died off while the butter was being incubated because of limited food or because of the presence of poisonous products of metabolic activity. The deterioration may have been more concerned with chemical than with biological causes. Another possibility is that the right balance of associative action was present in order to cause marked deterioration although the actual proteolytic counts were low.

Table 4 is even more significant when the distribution of the counts of 100,000 or more proteolytic organisms per ml. are examined. Further tabulation shows that, of the samples dropping less than two points, only 6.1 per cent had counts of 100,000 or more, while of the samples which dropped two or more points, 34.6 per cent had counts falling within this range.

It is believed that proteolytic organisms are an important factor in the development of putrid flavors in butter. It was found that the samples which developed this flavor during the holding period had higher proteolytic counts than did the samples which developed other off flavors. Thirty-three and six-tenths per cent of the samples which developed putrid flavors had proteolytic counts of 100,000 or more. Of those which developed rancid flavors, old cream flavors, and those which did not change in score, 16.6, 11.1, and 4.5 per cent respectively, had proteolytic counts of 100,000 or more.

The samples were also plated at the end of the ten day holding period for the enumeration of lipolytic micro-organisms. Tributyrin agar and nile blue sulfate agar were used. Incubation was for five days at 21° C.

The tributyrin medium, as modified from that suggested by Anderson (1), consisted of Standard Nutrient Agar base, plus 0.1 per cent sodium taurocholate, plus 1.0 per cent tributyrin. The final reaction was pH 6.8 to 7.2.

The nile blue sulfate medium, as modified from the one suggested by the American Dairy Science Association Sub-committee on the Microbiological Methods of Examining Butter (8), consisted of 0.5 per cent tryptone (Difco), 1.5 per cent agar agar, 0.5 per cent skim milk, 5.0 per cent of a 0.1 per cent nile blue sulfate solution, and 10.0 per cent of a butterfat emulsion containing 4.0 per cent butterfat and 0.5 per cent agar agar. The sterile fat emulsion and skim milk were added just before pouring the plates. The final reaction of the medium was pH 6.8 to 7.2.

The results of plating these samples of butter on the two media for the detection of lipolytic bacteria are given in Tables 5 and 6.

TABLE 5

Relation of lipolytic count on tributyrin medium to drop in score of butter held for ten days at 15.5° C.—Total of 63 samples

Drop in Score	0	1	1.5	2	2.5	3	3.5	4 or more
No. of Samples	16	6	9	10	5	9	3	5
Log. Av. of Counts	120,000	150,000	130,000	890,000	480,000	590,000	1,350,000	680,000

Table 5 shows a very marked relation between high lipolytic counts on tributyrin medium and poor keeping quality during the ten day holding

TABLE 6

Relation of lipolytic bacterial count on nile blue sulfate medium to drop in score of butter held for ten days at 15.5° C.—Total of 101 samples

Drop in Score	0	1	1.5	2	2.5	3	3.5	4 or more
No. of Samples	22	9	17	22	9	12	4	
Log. Av. of Counts	7,400	9,200	21,500	117,500	17,000	38,000	26,000	2,050

period. Further tabulation gives a logarithmic average of 127,000 per ml. for the samples which dropped less than two points, while those which dropped two or more points had a logarithmic average count of 700,000 per ml. of butter.

Table 6 shows a marked tendency for high lipolytic counts on nile blue sulfate medium to be associated with poor keeping quality, except in the case of those samples which decreased 4 or more points in score. There is, however, a less direct relation between lipolytic count and keeping quality when this medium is used than when the tributyrin media was used.

SUMMARY AND CONCLUSIONS

The data presented show that salted butter made from sour cream presents a problem as far as keeping quality at 15.5° C. is concerned. Twenty-five per cent of the 504 samples received from September to May dropped at least one and one-half points in score. This deterioration was found among the samples submitted by a large number of different creameries.

The samples which had an original score of 89 to 89.5 points had better keeping quality than did higher scoring butter and slightly better keeping quality than did the butter which scored less than 89. The month in which the butter was made did not significantly influence its deterioration.

A limited relation between the microscopic picture and keeping quality of the butter was found. Large numbers of rod-shaped organisms were, in general, associated with poor keeping quality. There was no relation between keeping quality and numbers or arrangement of cocci.

There was a marked relation between high proteolytic counts on tryptone-skim milk agar and poor keeping quality.

A marked relation was found between high lipolytic counts on tributyrin medium and poor keeping quality. This relationship was less marked when nile blue sulfate medium was used.

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THE CORRELATION BETWEEN ORGANISMS FOUND MICROSCOPICALLY IN BUTTER SERUM AND THE GRADE OF CREAM FROM WHICH THE BUTTER WAS MADE

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Quality in butter is becoming a more important issue to the industry each year. Since butter quality depends on the grade of cream, the cream usually has been graded in accordance with the kind of butter it will make. Grading is accomplished by the senses of taste and smell. In this study an attempt was made to determine the grade of cream by a microscopic examination of the organisms in the butter serum. This also included studies on varied lengths of storing butter, effects of culture, and a possible relationship between specific flavor defects and certain micro-organisms. Not all deterioration of cream is bacteriological so the grade may be lower than the organisms and their action would indicate.

PREVIOUS INVESTIGATIONS

Nelson (1) studied microscopic slides of butter with the view of predicting its keeping quality during storage for 7 days at 21° C. Clumps of well stained thin rods were generally a sure sign that deterioration would take place, especially in unsalted butter. The keeping quality was correctly predicted on 96.4 per cent of the commercial salted samples, 79.6 per cent of the unsalted and 84.9 per cent of the exhibition butter.

Nelson and Hammer (2) found that butter culture streptococci generally developed little or not at all in salted butter held at a favorable growth temperature. Organisms other than streptococci sometimes showed growth, this growth depending on the species present. In unsalted butter both streptococci and organisms other than streptococci developed at a favorable temperature.

Macy, Coulter and Combs (3) obtained decreased counts on salted butter held for 30 days; molds 66.7 per cent, yeasts 80 per cent and 73.3 per cent for bacteria. These decreases did not follow a consistent pattern.

PROCEDURE

Cream of all grades was procured and scored by two experienced judges according to the grade of butter it would make. Sweet and clean cream which should produce butter scoring 93 or above was graded "excellent," clean and sour cream scoring $91\frac{1}{2}$ to $92\frac{1}{2}$ was graded "good," and cream graded "fair," which scored 90 to 91 was sour with some off flavor. Cream

Received for publication January 18, 1938.

scoring below 90 was graded "poor." After scoring a microscopic slide was prepared from each sample. The cream was pasteurized at 68 to 71° C., held for 30 minutes, cooled to 7° C., held over night at 4° C., churned in a small experimental churn, buttermilk drained, butter washed, salted and worked. A sample of butter was then taken in 4 ounce bottles and held at 4° C. until slides were prepared of it.

Cream slides were prepared by the Fay (4) method. It consisted of 0.1 ml. of cream, one drop of sterile water, and one drop of Mayer's egg-glycerine mixture spread on one-half the surface of a slide. This was dried, dipped in alcohol for 20 seconds, dried and immersed in xylene for two minutes, dried and stained for one minute in methylene blue. Butter slides were prepared according to Nelson and Hammer (5). Melted butter was centrifuged in a separatory funnel and the non-fatty layer, serum, drained. One hundredth of a ml. was spread over 1 square centimeter, dried, stained with Newman stain (6), washed, dried, and restained with methylene blue.

RESULTS

One hundred and thirty samples were studied in the preliminary work to acquire a knowledge of the microscopic appearance of butter slides for the grades of cream "excellent," "good," "fair," and "poor." The following appearances of butter slides were correlated with the various grades of cream: (1) Butter from "excellent" grade cream showed a few well stained micro-organisms. Those present were cocci singly, in pairs, or chains. The use of culture increased the number of organisms present. No rods and only a very few yeasts were ever seen. (2) Slides of butter from "good" cream had a large number of well stained micro-organisms most of which were cocci singly, in pairs, or chains. A very few partly decomposed cells, occasionally occurred and a very few yeasts or molds. (3) "Fair" grade cream gave butter whose slides had an exceedingly large number of well stained micro-organisms. Most were cocci singly, in pairs, and in chains. The slides frequently showed many poorly stained and partly decomposed cells, a few rods, yeasts, and molds. (4) Slides from butter made of "poor" grade cream had a large to enormously large number of organisms, a majority of these were stained poorly and partly decomposed. Often slender rods existed; many times yeasts and molds were present.

The results of the study were grouped according to the grade of cream. On table 1 are tabulated the studies of butter made from cream scoring "excellent." A total of 143 different samples of butter was examined, of which 33 were stored for 1–3 days before preparing the slides. The grade was determined correctly by the microscopic examination on 90.9 per cent of the samples. For the 7-day holding, 95.4 per cent of 22 samples were correctly graded. Of the 56 samples held 14 days, 89.3 per cent were graded rightly. The fourth group consisted of 32 samples held 30 days, and 93.7

per cent were graded accurately. The average of the four holding periods was 91.6 per cent correct out of 143 samples. The number of samples of other grades incorrectly called "excellent" was small; 9.6 per cent of 125 in the "good" cream class, 1.8 per cent of 159 in the "fair" class and 4.2 per cent of the 97 "poor" cream samples. This is a total of 4.9 per cent mis-graded as "excellent" from 371 samples.

TABLE 1

Butter churned from "excellent" cream scoring 93 or above

	Storage Period			
	1–3 days	7 days	14 days	30 days
Total Samples	33	22	56	32
Number graded right	30	21	50	30
Number graded wrong	3	1	6	2
Number missed 1 grade	3	1	1	1
Number missed 2 grades	0	0	0	1
Number missed 3 grades	0	0	5	0
Per cent graded right	90.9	95.4	89.3	93.7

Table 2 contains the information on butter churned from "good" cream. Thirty-three samples were held 1 to 3 days and 63.6 per cent were graded correctly, 24 samples held for 7 days and 66.6 per cent graded correctly, 37 samples held 14 days of which 43.2 per cent were graded correctly. In the group held 30 days, 64.5 per cent were graded correctly from 31 samples. The total of the four holding periods amounts to a percentage of 58.4 right from 125 samples. The percentage of other grades incorrectly called "good" were: "excellent" 4.1, "fair" 27.6, and "poor" 19.5, giving a 17.2 per cent total on the three grades.

The tabulations for "fair" cream was recorded on table 3. The group stored for 1 to 3 days contained 57 samples and only 43.9 per cent were

TABLE 2

Butter churned from "good" cream scoring 91½ to 92½

	Storage Period			
	1–3 days	7 days	14 days	30 days
Total Samples	33	24	37	31
Number graded right	21	16	16	20
Number graded wrong	12	8	21	11
Number missed 1 grade too high	1	2	4	5
Number missed 1 grade too low	8	3	5	5
Number missed 2 grades too low	3	3	12	1
Per cent graded right	63.6	66.6	43.2	64.5

accurately graded. In 7 day lots 60.0 per cent were ascertained rightly from 20 samples and 40.0 per cent of the 40 samples in storage 14 days. Forty-two samples were stored in the 30 day lot of which 35.7 per cent were graded correctly. The percentage correctly graded was 42.7 for 159 samples in all four storage groups. Other grades erroneously called "fair" consisted of "excellent" 0.7 per cent, "good" 16.3 per cent and "poor" 22.6 per cent, giving a total of 12 per cent from 365 samples. These results seem to indicate that butter from cream scoring 90 to 91 cannot be accurately graded by the microscopic method. Factors such as chemical action and absorbed flavors apparently have a more important rôle in lowering cream to "fair" grade than was the case in the two higher grades of cream.

TABLE 3

Butter churned from "fair" cream scoring 90 to 91

	Storage Period			
	1–3 days	7 days	14 days	30 days
Total Samples	57	20	40	42
Number graded right	25	12	16	15
Number graded wrong	32	8	24	27
Number missed 1 grade too high	19	3	9	13
Number missed 2 grades too high	2	5	15	1
Number missed 1 grade too low	11	0	0	13
Per cent graded right	43.9	60.0	40.0	35.7

Table 4 shows the results for cream scoring below 90, "poor" grade. Seventeen samples were held 1 to 3 days and 47.0 per cent graded properly. Of the 10 held 7 days 70 per cent were given the correct grade. For 14 days 62 samples were stored, of which 54.8 were graded accurately. A percentage of 38.5 was corretly graded for the 8 samples stored 30 days.

A summary of the four groups shows that 97 samples were examined and

TABLE 4

Butter churned from "poor" cream scoring below 90

	Storage Period			
	1–3 days	7 days	14 days	30 days
Total Samples	17	10	62	8
Number graded right	8	7	34	3
Number graded wrong	9	3	28	5
Number graded 1 grade too high	8	1	11	2
Number graded 2 grades too high	1	1	15	2
Number graded 3 grades too high	0	1	2	1
Per cent graded right	47.0	70.0	54.8	38.5

53.6 per cent of these correctly graded. The "excellent" grade erroneously ascertained as "poor" was 3.4 per cent, "good" 15.1 per cent and "fair" 27.6 per cent, making a total of 15.9 per cent for 427 samples. The microscopic examination was successful in determining the grade for "poor" cream in only about fifty per cent of the cases. This was explained by the fact that many times a large number of the micro-organisms had completely decomposed, thus giving the appearance of a higher grade.

Altogether 524 samples composed the entire study of the four grades. The percentage determined correctly equaled 61.8.

A comparison was conducted on the same butter, one sample held 1 to 3 days and the other 30 days. A total of 103 churnings was studied consisting of "excellent" "good" and "fair" grades. In both storage periods the same percentage of 62.2 was graded correctly, indicating neither holding period was advantageous. A change occurred in the butter micro-flora during the 30 day holding, but this change caused some samples to be graded correctly that were missed in the 1 to 3 day storage and vice versa.

Culture organisms were added to approximately half the entire samples studied. The conclusions drawn from the results on the four grades indicated that the presence or absence of culture organisms did not influence the accuracy of the microscopic determinations. The number of culture organisms was considerably greater in butter from "excellent" cream than from "fair" cream when adding the same amount. This seemed to verify the observation that culture has more effect on high quality cream than on poorer cream.

Samples of the "fair" grade were obtained from commercial plant operations to compare with those churned by the laboratory procedure. Of the 55 commercial samples 30.9 per cent were correctly graded and 48.1 per cent of the 106 laboratory samples. The difference was not considered large enough to more than suggest that the commercial samples might be a trifle harder to grade correctly.

A study of the data on butter slides for a possible correlation between certain micro-organisms and specific flavor defect in cream was negative. The only means of distinguishing among the stained micro-organisms was in size, shape, and whether they occurred singly, in pairs, or in clumps. This was insufficient information to correlate organisms with specific flavor defect in the cream.

SUMMARY

The data recorded in the study consisted of sample number, cream score, criticisms of flavor, appearance of the cream slide, and appearance of the stained butter serum.

In the preliminary work 130 samples were studied for the purpose of determining the microscopic appearance of the butter serum. This informa-

tion was correlated with each of the four grades of cream from which the butter was churned. The grades of cream used in making the butter were "excellent" scoring 93 or above, "good" 91½ to 92½, "fair" 90 to 91, and "poor" below 90 in score.

The stained slides of 524 samples of butter were studied under the microscope and the grade of cream predicted. Of these 524 samples, 143 were from the "excellent" group and 131 (91.6 per cent) were given the correct grade. In the "good" group there were 125 samples. Seventy-three (58.4 per cent) were accurately graded. One hundred and fifty-nine samples of the "fair" group were examined and 68 (42.7 per cent) had the right grade predicted. In the last group 52 (53.6 per cent) of the 97 "poor" group samples were graded accurately. This seems to indicate that the microscopic examination was fairly accurate in distinguishing butter made from "excellent" cream, but for lower grades it was not a reliable method.

Storage periods of 1 to 3 days, 7 days, 14 days, and 30 days did not materially influence the number of grades determined correctly. This was verified by a trial in which one-half the samples was held for 1 to 3 days and the remaining samples 30 days. The percentage determined correctly from 103 churnings was the same (62.2) for both storage periods.

The presence or absence of culture organisms did not effect the microscopic grading.

The results on studies of the "fair" group indicated samples from commercial churnings were slightly more difficult to grade correctly than those from the laboratory procedure. This was apparently caused by the difference in handling conditions.

The two apparent reasons for not being able to determine the "good," "fair," and "poor" grades as accurately as the "excellent" grade were: (1) Low scoring cream was not always the result of bacteriological action but was caused by chemical action and absorbed feed flavors. (2) The other reason was the contamination by organisms subsequent to pasteurization of cream and during the churning process.

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NOTE ON VIOLET RED BILE AGAR FOR DETECTION OF *ESCHERICHIA COLI*

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Since most of the reported work using Violet Red Bile Agar for the detection of *Escherichia coli* has been on a theoretical laboratory scale, herewith is reported a practical application that yielded such satisfactory results that it appears worthy of mention.

A dairy, located in one of the North Central States, was having difficulty with a re-contamination by *Escherichia coli* after the milk received a heat treatment of 170° F. for 30 minutes. The finished product of this dairy could not be marketed unless the material was free from *Escherichia coli.* It was feared that perhaps the organism was getting into the heated milk from the spray pond water which was used as condensing water in the evaporator and dryer. In an attempt to trace this source of *Escherichia coli,* the authors were invited as consultants.

Samples of the milk, secured at various points in the process after the milk had been heated as described above, were tested for the presence of *Escherichia coli.* Two different methods were used for the detection of the organism; namely, (1) inoculating the milk into Brilliant Green Bile Broth 2% Medium for the presumptive test followed by streaking on Eosin-Methylene Blue Agar from the tubes that showed gas production, and, (2) plating the milk directly, using Violet Red Bile Agar as the medium. On the last named medium the organism produces small, purplish red colonies which are surrounded by a zone of precipitated bile after an incubation period of 18 to 24 hours at 37° C.

Over a hundred samples were tested for the presence of *Escherichia coli* and in every instance when typical colonies of this organism developed on the Violet Red Bile Agar in 18 to 24 hours, corresponding, confirmed-positive results were obtained in 48 hours using the other method. On the other hand, when gas was produced in the Brilliant Green Bile Broth which gave a spurious test on the confirmation medium, no typical colonies were produced on the Violet Red Bile Agar, so that, during the practical application of these two methods in the detection of *Escherichia coli,* perfect correlation was obtained.

Using the direct plating method that gave results in 18 to 24 hours as compared to the 48 hours required by the Brilliant Green Bile Broth and Eosin Methylene Blue Agar method, changes could be made within 24 hours after the samples were taken to correct or eliminate conditions that were a

Received for publication March 21, 1938.

possible source of re-contamination. Whereas if the results were not obtained before 48 hours, no changes could have been started until two days had elapsed after the samples were taken. Hence much time and expense were saved by accepting the results of the Violet Red Bile plates which enabled the necessary corrections and alterations to be made before the day's manufacturing started thereby maintaining the daily production schedule.

The results obtained raise the question, "When *Escherichia coli* did make its appearance was the recontamination sufficiently heavy to make both of these methods equally sensitive?" In this study no attempt was made to determine the relative sensitivities of these two media. Nevertheless, the fact remains that, using the results obtained with Violet Red Bile Agar to solve the practical problem described, much time and material were saved.

LEUCOCYTES AND THE METHYLENE BLUE REDUCTION TEST[1]

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The observation is not infrequently made that some samples of milk apparently of low bacterial content have unexpectedly short reduction times. It has been customary to explain this phenomenon by assuming a reducing activity for milk leucocytes, although unequivocal acceptance of this explanation is not always possible in the absence of any more adequate measure of bacterial numbers than the methylene blue reduction test itself. In the present study an attempt has been made to use more delicate criteria of the influence of bacteria on the reduction times of such milks than the plate count or a cursory preliminary microscopic examination of the milk.

HISTORICAL

Skar (6) demonstrated reduction of methylene blue in sterile milk by leucocytes from the lymph gland of a steer. He believed that a leucocyte content up to approximately 6.7 million per cc. cannot reduce methylene blue in milk in the standard test but that leucocytes effect reduction of the dye if they are kept evenly distributed by periodic agitation of the milk during incubation.

Barthel (1), although recognizing the reducing power of leucocytes, is not inclined to attribute to this power great importance in milk control.

Wilson (9) concurs in the opinion that leucocytes are a factor in the reduction test but was unable to effect any marked decrease in "aerobic" reduction times of milks to which suspensions of rabbit leucocytes were added.

Ramsdell (5) observed a general but not direct relation between the reduction of resazurin and the leucocyte content of milk but was unable to demonstrate reduction of either resazurin or methylene blue by washed leucocytes. He believed "the cause of reduction must be the result of the presence of substances associated with cells, or substances present in abnormal milks in amount comparable to the cell content."

Devereux and Bryan (2) and Hastings (4) regard leucocytes as being significant in the reduction test, at least in better class milks.

METHODS

The technique of collection and analysis of the milk samples is described elsewhere (7) and will not be repeated here. Plate counts are not reported

Received for publication March 20, 1938.

[1] The data contained herein are taken from a thesis presented by N. J. Strynadka (now Inspector of Dairy Products, Dairy and Cold Storage Branch, Dominion Department of Agriculture) at the University of Alberta in partial fulfilment of the requirements for the degree of Master of Science.

as they were found to contribute practically nothing to the study. The Breed counts refer to bacteria only and the number of examined fields from which they were computed is in each case cited except when the bacterial content was in the millions in which case usually 5 microscopic fields per Breed smear were counted.

The leucocyte counts are computed from the examination of 60 microscopic fields per Breed smear except when the count was very high in which case fewer fields were observed. All cells other than the cells of microorganisms were classed as leucocytes and differentiation of kinds of leucocytes was not attempted. All bacterial and leucocyte counts are on a per cc. basis and the methylene blue reduction times are reported in hours and minutes, 1:45 meaning 1 hour and 45 minutes.

CORRELATION BETWEEN LEUCOCYTE COUNTS AND REDUCTION TIMES

The coefficient of correlation between the leucocyte counts and the standard methylene blue reduction times of 158 samples of aseptically-drawn milk was found to be 0.698 ± 0.027. This constant as a sole criterion is not sufficiently high, in the opinion of the authors, to justify the popular assumption that milk leucocytes reduce methylene blue in milk.

THE INITIAL BREED COUNT

The initial 1000 field Breed counts are available for 95 of the 158 samples of milk and show that in the large majority sufficient bacteria were probably present to account for reduction through bacterial action irrespective of the leucocyte count which sometimes was very high. There were a few exceptional samples having leucocyte counts over 1 million, reduction times of less than 10 hours and low Breed counts. There were also 6 samples with low leucocyte and Breed counts and short reduction times. It is probable that the initial 1000 field Breed count when applied to this type of milk is not a sufficiently precise measure (7) to justify a conclusion from the foregoing data further than that in the majority of the samples the bacterial content was high enough to account for reduction of the dye independently of the leucocytes.

THE BACTERIAL CONTENT AT THE TIME OF REDUCTION

It has been shown that in samples of this class of milk about which there is no suspicion of abnormality the bacterial content at the moment of reduction is many millions per cc. as measured by the Breed count (8). It would appear sound to assume that in such samples the only practically significant reducing influence is exerted by the bacterial cells. In our present state of knowledge the number of bacteria at the time of reduction seems to be the most precise criterion of the preponderating influence of the bacteria on the reduction time.

The Breed counts at the moment of reduction were found to be over 60 million in 34 of 46 samples of aseptically-drawn milk. The reduction times of 19 of these samples were less than 10 hours but the Breed counts on reduction of 7 of these samples were over 60 million. The remaining 12 milks (tables 1 and 2) are interesting exceptions.

TABLE 1

Ten milks reacting abnormally to the reduction test

Milk number	Reduction time	Leucocyte count	Initial 2000-field Breed count	2000-field Breed count at reduction	60-field Breed count after total of 8 hours incubation
1	0:30	47,400,000	477,000	68,400	590,000
2	0:45	17,800,000	107,000*	253,800*	
3	0:55	8,300,000	142,000	86,000	670,800,000
4	1:45	4,160,000	119,700	364,200	
5	1:45	5,340,000	91,200	59,700	
6	1:45	15,960,000	48,000	43,000	6,000,000
7	2:10	7,520,000	335,000	146,000	920,000
8	3:30	4,150,000	200,700	56,400	140,000
9	5:00	680,000	39,200	81,600	210,000
10	7:15	3,500,000	56,100	435,600*	

* 1000-field count.

The initial plate counts of these 12 exceptional milks varied from 50 to 7600 per cc. but the initial Breed counts were in some cases rather high. The 2000 field Breed count at reduction was in only 1 sample over 0.5 million while the leucocyte counts were low (less than 1 million) in 2 samples.

These data are not clear-cut evidence that the leucocytes possessed a reducing power. From the point of view of numbers only it is difficult to attribute to 4 million leucocytes in one milk a reducing power of 1:45 and to 3.5 million in another a reducing power of 7:15 while it took 16 million in a third 1:45 to reduce the dye. Samples 9 and 12 were low in leucocytes and in bacterial content at reduction. When these two milks are considered with the six exceptional milks mentioned in the preceding section entitled *The Initial Breed Count* (one of which had a reduction time of 6:45, an initial 1000 field Breed count of 6000 and a leucocyte count of 180,000) the reducing power of the leucocytes is not a tempting explanation of the short reduction times.

For research purposes in this laboratory the standard methylene blue reduction test is routinely supplemented by the modified reduction test (hourly or half-hourly agitation of the tubes during incubation). Occasionally samples of aseptically-drawn milk were encountered which had considerably longer modified than standard reduction times. In each case where the particulars of the animal giving such milk was available a history

TABLE 2

Two milks reacting abnormally to the reduction test

Milk No.	Reduction time		Leucocyte count	Initial Breed count	Fields examined	Breed count at reduction	Fields examined	60-field Breed count after 8 hrs. incubation	Breed count at (modified) reduction
	Standard	Modified							
11	5:00	7:15	2,100,000	143,100	2,000	1,017,600	1,000	18,660,000	127,200,000
12	6:15	14:45	860,000	75,000	1,000	132,800	2,000	350,000	64,200,000

of udder abnormality was found. In two such milks, reported in table 2, it is evident that bacterial action was responsible for the modified but not the standard reduction times.

These results do not confirm Skar's theory that shortened reduction times in the modified test are due to the more even distribution of the leucocytes because of agitation. A few samples of aseptically-drawn milk of short standard reduction times, including samples 11 and 12, were encountered which when shaken immediately after reduction had second reduction times varying up to 10 to 12 hours. It is, indeed, difficult to accept the reducing power of the leucocytes as the explanation of these observations.

It is doubtful if the 2000 field Breed count is sufficiently accurate to justify the conclusion that phagocytosis was responsible for lower Breed counts at the time of reduction than initially in any of these milks. It is possible that bacterial reproduction was continuous in all of these milks but was not apparent because of phagocytic action of the leucocytes. Nothing was observed that caused suspicion that this phenomenon was operative and the modified reduction times of milks 11 and 12 are not in support of such a theory.

THE ADDITION OF LEUCOCYTES TO MILK

In 1913 Skar (6) reported the reduction of methylene blue in sterile milk by an added suspension of leucocytes from the lymph gland of a steer. Gay

TABLE 3

The reduction times of milk plus bovine blood leucocytes

Tube number	Description of samples	Modified reduction time	Breed count at reduction
1	Milk only	12:30	
2	" "	12:45	
3	" "	13:15	
4	9 cc. milk + 1 cc. leucocyte suspension*	11:00	200,000,000
5	9 cc. milk + 1 cc. from Tube 4	11:45	
6	9 cc. milk + 1 cc. from Tube 5	12:15	
7	9 cc. milk + 1 cc. leucocyte suspension*	10:45	190,000,000
8	9 cc. milk + 1 cc. from Tube 7	11:30	
9	9 cc. milk + 1 cc. from Tube 8	12:45	
10	9 cc. milk + 1 cc. blood serum	12:00	120,000,000
11	9 cc. milk + 1 cc. from Tube 10	12:00	
12	9 cc. milk + 1 cc. from Tube 11	12:45	
13	9 cc. milk + 1 cc. red blood cell suspension	11:00	126,000,000
14	9 cc. milk + 1 cc. from Tube 13	12:30	
15	9 cc. milk + 1 cc. from Tube 14	12:30	

* By computation this milk leucocyte suspension mixture contained approximately 50 million leucocytes per cc.

and Oram (3) demonstrated the reduction of methylene blue in sterile broth in the presence of leucocytes. The failure of the leucocytes to reduce methylene blue similarly in the presence of a streptococcus filtrate was ascribed to a leucocyte-destroying activity of "streptococcus leucocidin."

In the present study blood was drawn aseptically from the jugular vein of a Jersey cow into a flask of sterile physiological saline solution. The leucocytes were separated by repeated centrifugalization, decantation and washing in sterile saline solution until finally a clear suspension of approximately 500 million leucocytes per cc. was obtained. This suspension as well as clear serum and a suspension of the separated red blood cells was added to milk drawn asceptically from the udder of the same cow in varying proportions as outlined in table 3. The animal from which the blood and milk were drawn had not had a recognized udder abnormality while the milk had a standard reduction time of approximately 25 hours and a leucocyte count of 330,000. Only modified reduction times are reported in tables 3 and 4 because the normal variation of reduction times in replicate tubes of this milk militates against an intelligent interpretation of the standard reduction time results. It cannot be said with certainty that either the added leucocytes, red blood cells or blood serum had a measurable effect on reduction times. Whatever effect there may have been was small and was the same for red blood cells as for leucocytes. Sufficient bacteria were present at reduction to account for reduction.

Efforts to stain the leucocytes after their addition to the milk failed. It was thought that the loss of staining properties might be accompanied by loss of reducing power. In an endeavor to study the effect of adding to milk leucocytes retaining their staining properties 200 cc. of sterile physiological saline solution were injected intraperitoneally into a rabbit early in

TABLE 4

The reduction times of milk plus rabbit leucocytes

Description of samples	Modified reduction time, Tube 1	Modified reduction time, Tube 2	Leucocyte count	Breed count at reduction
45 cc. milk + 10 cc. leucocyte suspension	11:00	12:00	1,120,000*	66,400,000
45 cc. milk + 7 cc. leucocyte suspension	11:00	12:00	730,000	68,400,000
45 cc. milk + 3 cc. leucocyte suspension	11:00	11:00	590,000	77,200,000
45 cc. milk + 0.5 cc. leucocyte suspension	10:30	10:30	520,000	70,400,000
Milk only	10:00	10:30	340,000	
45 cc. milk + 10 cc. saline solution	11:00	11:00		84,000,000
45 cc. milk + 5 cc. saline solution	10:30	11:00		

* By computation this milk leucocyte suspension mixture contained 2,096,363 leucocytes per cc.

the morning followed by a further injection of 100 cc. late in the afternoon. Three hours later 200 cc. of exudate were removed by aspiration. By centrifugalization, decantation and washing in sterile saline solution a suspension containing approximately 10 million leucocytes per cc. was finally obtained. Milk from the same animal as previously used was treated immediately as outlined in table 4. It is seen that the leucocytes retained their staining properties in fair degree after their introduction into the milk but no decrease in reduction time is noticeable.

Since the completion of these experiments Wilson (9) reported reduction times of raw and pasteurized milks to which varying concentrations of rabbit leucocyte suspensions were added. Although he believes that reduction by leucocytes was demonstrated, he observes that "the results were a little irregular" and "extremely difficult to understand."

DISCUSSION AND CONCLUSIONS

The mere presence of leucocytes in milk, even in large numbers, and the absence of bacteria in large numbers do not prove a reducing power for the leucocytes. The attempts to furnish proof of such a reducing power have to date depended on strictly quantitative measurements and in the opinion of the writers have been unsuccessful. The need for qualitative measurements seems apparent.

The observations reported in the literature and in this paper are explicable in terms consistent with accepted theories of dye reduction in milk. There are reasons for believing that the abnormal udder conditions responsible for milk of high leucocyte content are also responsible for abnormally high concentrations of reducing substances in the milk. The presence of reducing substances in abnormally high concentrations would explain the observations under discussion without soliciting aid from the leucocytes. This is not, of course, a denial of the possibility of some leucocytes possessing reducing properties but the bulk of the evidence is that leucocytes are rarely, if ever, the main or significant influence in the reduction of methylene blue in milk in practice.

ACKNOWLEDGMENTS

The authors gratefully acknowledge financial support from dairy interests within the province, and the assistance of Dr. M. M. Cantor of the Department of Biochemistry, Dr. D. R. Climenko of the Department of Physiology and Pharmacology, and the Department of Animal Husbandry in the procurement and fractionation of the blood samples.

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THE VISCOSITY OF ICE CREAM MIX MADE WITH PLAIN AND SUPERHEATED CONDENSED SKIM MILK

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Ice cream manufacturers at one time were convinced that good ice cream mix should be viscous. Processing mix in homogenizers was not a common practice at that time and it is not unlikely that a viscous mix was desirable under the freezing, storage, and handling conditions which prevailed. With the wider use of the homogenizer, better freezers and better methods of distribution, it was later demonstrated that high viscosity was of no special value and in recent years the trend has been towards mixes of low viscosity.

Various methods of increasing the viscosity of mix were employed at the time viscous mixes were deemed desirable, among them being the use of superheated condensed products. Superheated condensed milk is not widely used at the present time, probably because of its influence on the viscosity of the mix, difficulties in handling it, and its slight "cooked" flavor. However, some manufacturers find its use desirable, as it produces a type of ice cream which is popular in some localities.

Relatively little has been written on the use of superheated condensed milk in ice cream. Tracy (1) found an improvement in texture and body of the ice cream and its resistance to melting when superheated solids were used. He also noted an increase in the mix viscosity. Williams and Hall (2), using a sales-preference test as a means of determining desirable types of ice cream, found that the use of superheated condensed skim milk produced a better ice cream than plain condensed. Johnson and Ward (3) have shown that the viscosity of superheated condensed milk is not a true index of the value of milk for bread making, but observed that it is superior to condensed milk which has not been superheated. They state that it is the heat treatment accorded the milk which operates to improve the baking quality of the milk, and this may or may not be reflected in the viscosity of the product.

In the manufacture of superheated condensed milk, the temperature is raised to 185–195° F., by injecting live steam into the product before removing it from the vacuum pan. This treatment causes a thickening of the product, the degree of thickening depending on the time and temperature of heating. The heating is discontinued at the point of maximum thickening as any overheating results in a coarse coagulation of the product. Over cautious and inexperienced operators usually stop heat-

Received for publication March 22, 1938.

ing before the point of maximum thickening, and thus the benefits of properly superheated milk are only partially obtained. Since superheating, when properly conducted, brings about a marked increase in viscosity, it is to be expected that the beneficial effects of superheating are often attributed to the increase of viscosity and this property is frequently used as a measure of its value for ice cream.

The viscosity of ice cream mix and its influence on the freezing properties and quality of the finished ice cream has been studied by a number of investigators. Leighton and Williams (4) first showed that ice cream mix had an "apparent" viscosity after proper aging and that agitation, such as is given the mix in the freezer, reduced this to a lower value which they termed "basic" viscosity. Following the work of these authors, most investigators used the term "basic" viscosity as that which results when the mix is strongly agitated as in the freezer or with special devices designed for this purpose (6), although Hening (5) recommends homogenization of aged mix as a means of obtaining the "basic" viscosity. It is probable that the action of the homogenizer is more drastic than the dashers of a freezer and, therefore, the method of Hening may give viscosity values below those which are of actual interest in the manufacture of ice cream.

During the course of some investigational work on superheated condensed skim milk, it was observed that the viscosity could be markedly reduced by homogenization. The terms "apparent" and "basic" viscosity, suggested by Leighton and Williams (4) for ice cream, were used to describe the viscosity of this product before and after homogenization.

It is the purpose of this paper to record the observations made during a study of the effect on ice cream of using superheated condensed skim milk which had been reduced by homogenization to its basic viscosity in comparison with plain condensed skim milk and with superheated which had not been treated to reduce its viscosity.

EXPERIMENTAL

Determination of viscosity: In this work the viscosity of the various products was determined by means of a Saybolt viscosimeter having an orifice of 0.082″ diameter. The time required for 60 cc. of the product to run through at the designated temperature was taken as the viscosity. The Saybolt tube was mounted in a water bath to insure accurate temperature control. All samples were aged over night at 40°F. before viscosity determinations were made.

Preparation of the condensed products: Plain condensed skim milk and superheated condensed skim produced in a commercial plant were used throughout this experimental work. In preparing the homogenized superheated product, the material was passed through a single stage homogenizer

at a temperature of 125° and at pressure of 3000 lbs. per sq. in. and held a day at 40° before being used in the mixes.

Preparation of the mixes: All of the mixes made in this experiment were of the following composition:

Butterfat	13%
Milk solids not fat	11%
Sugar	15%

All of the milk solids not fat not supplied by the whole milk (4% fat) and cream (40% fat) were obtained from the condensed product under consideration. In those mixes made with gelatin, a gelatin of 160 Bloom was used in the amount of 0.4%. The mixes were compounded in the usual manner, pasteurized at 150° F. for 30 minutes, and homogenized in a two stage homogenizer using 2000 lbs. on the first valve and 1000 lbs. per sq. in. on the second valve, which gave a total of 3000 lbs. per sq. in. The mixes were cooled to 40°F. and aged over night.

Since the primary purpose of this study was to observe the influence of the viscosity of the condensed product on the viscosity of the mix, not all of the mixes were frozen into ice cream. However, a few of the mixes were frozen and for this a 40 qt. batch freezer was employed, the ice cream being drawn at 90% overrun. A record was made of the time required to reach this overrun and also of the general quality of the finished product after three days in the hardening room.

RESULTS AND DISCUSSIONS

Viscosity of the condensed products: Typical data on the viscosity of the condensed products and the resulting mixes are summarized in Table 1. It will be seen that when superheated condensed skim was homogenized a marked reduction in viscosity was obtained. Under the conditions of this experiment the viscosity of the homogenized superheated product was greater than that of the plain condensed but the difference, although noticeable, was small in comparison with the difference between the plain and the unhomogenized superheated. The superheated condensed which had been homogenized was of such viscosity that it could be handled easily, pouring readily and draining rapidly from cans.

Viscosity of mixes made without gelatin: Inspection of the data in Table 1 indicates that in those mixes made without gelatin there was practically no noticeable difference between the viscosity of the three mixes. The high apparent viscosity of the superheated condensed does not carry over into the mix, showing that the homogenization process given the mix is effective in reducing the viscosity of the mix to its basic viscosity. The small difference noted in both the apparent and basic viscosity between the one mix containing plain condensed skim milk and

the two mixes, made with superheated condensed, was due to the heat treatment these two products received, but since there was practically no difference between the mixes containing the homogenized and unhomogenized condensed, it may be said that the beneficial effects of superheating cannot be accurately measured by its viscosity.

TABLE 1

The viscosities of plain, superheated and homogenized superheated condensed skim milk and ice cream mixes made with these products

Kind of product	Total solids of product %	Viscosity of product at 50° F. Secs.	Viscosity at 40° of ice cream mix made with each source of M.S.N.F.			
			No gelatin used in mix		0.4% gelatin used in mix	
			Apparent viscosity Secs.	Basic viscosity* Secs.	Apparent viscosity Secs.	Basic viscosity* Secs.
Plain condensed skim milk	28.7	54	54	52	508	201
Superheated condensed skim milk	28.4	more than 36,000	69	67	about 1000	331
Homogenized superheated condensed skim milk	28.4	446	68	67	about 1000	336

* Mixes reduced to basic viscosity by means of a laboratory agitator in absence of air (6).

Viscosity of mixes made with gelatin: An amount of gelatin (0.4%) was used in these mixes to make a definite gel. From the data presented in Table 1 it will be seen that the presence of the gelatin increased the viscosity of the mix. The influence was chiefly on the apparent viscosity, which was comparatively high. However, the gelatin also increased the basic viscosity to a noticeable degree. The same essential differences in apparent and basic viscosity existed between the three mixes as was found in the mixes made without gelatin.

Freezing properties of the mix and quality of the ice cream: Very little difference in freezing time was noted in the few mixes which were frozen and the differences were not considered of commercial importance. It may be said, however, that in every case mixes made with plain condensed skim milk whipped very slightly faster than the other two mixes in the series.

In comparing the general quality of the three ice creams made in this series, it may be said that the ice cream made with the plain condensed skim was somewhat less smooth in texture and slightly weaker in body

than the two ice creams containing the superheated condensed products. This sample also differed from the other two in that it had a slightly less cooked flavor. As there was no difference in the texture, body and flavor between the ice cream made with the superheated condensed and the homogenized superheated condensed, it is evident that the homogenization of the condensed product had no effect on its value for ice cream as far as quality of the ice cream was concerned.

SUMMARY

Mix made with superheated condensed skim milk is but slightly more viscous than mix made with plain condensed skim milk.

The high apparent viscosity of superheated condensed skim milk can be reduced by homogenization to such an extent that the product may be easily poured and handled.

Reduction of the viscosity of superheated condensed by homogenization in no way influences the viscosity of ice cream mix.

The viscosity of superheated condensed is not a true measure of its value in ice cream mix.

Whatever beneficial effects are obtained by using superheated condensed skim milk, they are not the result of the higher viscosity, but are probably due to the high heat treatment accorded the product.

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THERMAL SHOCK RESISTANCE OF MILK BOTTLES

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The presence of significant numbers of thermal shock cracked bottles in the daily rejects of two large dairies was reported in a previous study (1). The present study was made in order to better understand the relation of thermal shock resistance of bottles determined by test to their failure in actual usage.

The thermal shock test for milk bottles was first introduced into the dairy industry in this country by Kouwenhoven (2) in 1926. The routine usage of a thermal shock test in the Chicago milk bottle exchange was reported in 1934 (3). Private concerns have used some form of the test for a number of years. The origin of the test in the glass business is probably lost in the antiquity of the art. Some effort has been made in recent years to study the limitations of the test and to standardize a method. It was announced in the spring of 1937 that the Glass Container Association had authorized a research project to develop standard bottle tests including the thermal shock test.

Although there appears to be some disagreement among glass technologists as to whether or not the thermal shock test is a general test for the strength of bottles, it is well agreed that much can be learned through its use about their thermal endurance in commercial usage. Inasmuch as the resistance of glass to compression is much greater than its resistance to tension, it is believed that tensile stresses are chiefly responsible for thermal, as well as impact breakage (4). The thermal shock test made by rapidly cooling hot bottles over various temperature ranges, applies a controlled trial tension to the bottle.

The thermal shock test used in this study was developed after much preliminary experimentation and was found to give reproducible results on representative samples of commercial bottles. The test is naturally somewhat empirical and is subject to human errors. All the tests reported here were made by one person who exercised all possible care.

THE THERMAL SHOCK TEST

Thermal shock tests were made in two square galvanized iron sinks approximately 36 inches long, 24 inches wide, and 24 inches deep. One was heated directly by gas flame and the other was kept cold by a small stream of cold water. The hot tank was equipped with a mechanical agitator and the cold tank was equipped with a constant level drain. The temperatures

Received for publication March 22, 1938.

were controlled to within 1°F. of the desired temperature. The hot tank had a false bottom of wood slats to prevent the bottles from resting on the heated metal surface. The depth of the water in each tank was regulated so that the bottles in an upright position were covered by $1\frac{1}{2}$ to 2 inches of water. The bottles to be tested were placed individually, using tongs, in the hot tank, allowed to fill slowly to warm, then emptied and submerged again. All the bottles were thus placed in the hot water at intervals of one minute. After 10 minutes or longer had elapsed, starting with the first and continuing in order at one minute intervals, the bottles were lifted out, inverted to empty, and plunged vertically bottom downward to the bottom of the cold water tank as rapidly as possible allowing them to fill under water. This operation required less than 5 seconds. As soon as all the bottles had been shocked they were carefully examined individually for cracks. Many of the cracks found were very fine and not very deep in the surface of the glass. Direct sunlight was more satisfactory than diffuse sunlight or incandescent-lamp light for the examinations. It was found that if the shocked bottles remained too long in the cold water or air after shocking the fine cracks closed and became invisible. The examinations were made, therefore, as soon as possible after the shocking.

TABLE 1

The effect of thermal differential on the resistance of quart bottles to thermal shock

Hot tank °F.	Cold tank °F.	Diff. °F.	No. of bottles tested	Cracked		Location of cracks
				No.	%	
			Lot A			
124	44	80	102	1	1.0	1—Lip
129	44	85	132	2	1.5	2—Lip and neck
134	44	90	40	3	7.5	3—Lip and neck
138	43	95	30	7	23.0	5—Lip and neck
						1—Shoulder
						1—Bottom
145	45	100	20	6	30.0	4—Lip and neck
						2—Bottom rim
147	42	105	19	9	47.0	6—Lip, neck, sides & bottom
						2—Lip and neck
						1—Bottom
			Lot B			
126	66	60	47	1	2.1	1—Lip
120	50	70	25	3	12.0	3—Lip and neck
130	50	80	20	4	20.0	4—Lip and neck
140	50	90	15	8	53.0	6—Lip and neck
						2—Bottom rim and sides

I. RELATION OF TEMPERATURE DIFFERENCE TO CRACKING

Two gross of new quart bottles of one make (Lot A) were carefully examined individually and the few damaged and flawed bottles found were discarded. Previous work had shown that the presence of surface defects reduces the normal resistance to shock. After thoroughly mixing the lot of bottles, sample portions were tested at thermal differentials varying from 80°F. to 105°F. in steps of 5°F. The results are shown in Table 1. The relation between thermal differential and percent of bottles cracked in this experiment is shown graphically in Fig. 1.

Another lot of bottles of the same make, but manufactured at a later date (Lot B), were tested in a similar manner. They were sampled from 7 gross of new bottles used in the bottle washer thermal shock experiments which will be described in Part III. Since they were found to be consider-

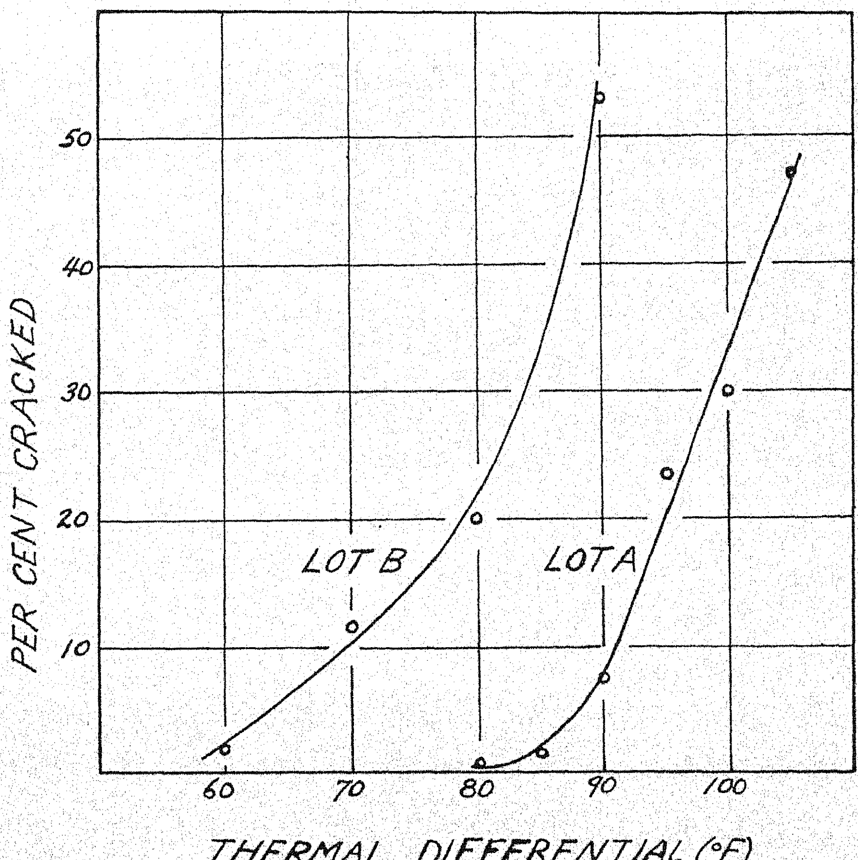

FIG. 1. Relation between thermal differential and per cent of cracked quart bottles in the thermal shock test.

ably less resistant to thermal shock than the first lot tested, the thermal differentials used were from 60°F. to 90°F. in steps of 10°F. The results are shown in Table 1. The relation between thermal differential and percent of bottles cracked is shown graphically in Fig. 1.

In each curve there is a leveling off below 10% cracked, indicating that there is a small percentage of bottles very low in thermal shock resistance. It should be pointed out that a range of bottle breakage as low as 0.1% to 1.0% is of economic importance in commercial milk plant operation. The cracks in these bottles were in the outer surface of the glass. In general, the cracks at low thermal differentials were shorter and more difficult to see than those at the higher differentials. These short fine cracks have been observed in newly washed bottles in commercial operations by individual inspection. The inspectors at the washer discharge almost invariably fail to see them. It will be noted that cracks did not develop in the bottom or side regions of the bottles except at greatest thermal differentials. This is contrary to the results obtained by Murgatroyd (5) who found that bottles cracked in the thermal shock test only in the wall near the base (bottom rim). In the test he used, the cold bottles standing in cold water up to the lip were filled with hot water. It is questionable whether the lip region is shocked as severely, by this method, as is the lower region. Considering the average cracking temperature or the temperature at which 50% were cracked, Lot A had a 15°F. favorable margin over Lot B.

II. EFFECT OF REPEATED THERMAL SHOCKS

A representative sample, consisting of 30 bottles, of a shipment of new quarts were tested at a differential of 90°F. (140° to 50°). The whole test was repeated a total of 20 times examining the bottles between each test and noting the effects of each shock. The results are recorded in Table 2.

The twenty bottles from Lot B, tested at 80°F. differential in Part I, were retested at 80°F. differential for 9 more consecutive times with examination between as previously described. The results are shown in Table 3.

It appears that repeated shocking resulted in continued breakage up to a limit which differed for the two lots tested. Murgatroyd (5) reported a similar effect of repeated shocking and attributed it to the inaccuracy of the test. It would appear that this effect is related to the inherent nature or weakness of the bottles and may be a type of fatigue influenced by the time element or the number of shocks. The cracks in most of the bottles were associated with the tiny impact marks which result when bottles strike together. There were impact marks, however, on the bottles which survived the shocking. This seems to indicate that the impact marks help determine the location or path of the cracks. Cracks in the bottoms and bottom rims of the bottles did not appear until the bottles were shocked a number of times. This region was also more resistant in the temperature differential tests.

TABLE 2

Thermal shock cracking of new quart bottles (Lot A) during 20 successive shocks at 90° F. differential

Bottle No.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	N	–	–	–	–	–	–	R	–	R, X	R, X, D						
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	L	–	–	–	–	–	–	X	–	–	–	–
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	L	–	–	–	–	R	–	–	D										
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	L	–	–	–	–	–	–	–	–	–	–
9	0	0	L	X	–	–	X	–	–	–	X	–	–	–	–	R	R, X	–	–	R, X, D
10	0	0	0	0	0	0	0	0	L	–	X	–	X, D							
11	0	N	X	–	–	X	–	–	D											
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	–	X, D			
14	0	0	0	0	0	0	0	0	0	B	–	–	R	R, X	–	–	–	–	X, D	
15	0	0	0	0	0	0	0	0	0	0	0	0	0	L	X	–	–	–	–	–
16	0	0	0	0	0	0	0	0	0	0	0	0	0	R	–	–	–	–	–	–
17	0	0	0	0	0	L	–	–	–	–	X	–	–	–	X, D					
18	0	0	0	L	–	–	–	–	–	–	–	–	–	–	–	–	R	R, X	–	R, X
19	L	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X, D			
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	–	–	–	–
21	0	0	0	0	0	0	0	0	0	0	0	L	–	–	–	–	–	–	–	R
22	0	0	0	0	0	0	0	0	L	–	–	R	–	R, X	–	–	R, X, D			
23	0	0	0	0	0	0	0	R	–	X	X	X	X, D							
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R	X	–	–
25	0	0	0	0	0	0	R	X	–	–	–	–	–	–	–	–	–	–	–	X
26	0	0	0	0	0	0	0	0	0	0	0	L	X	X	–	–	–	X	–	–
27	0	0	0	0	0	0	0	0	L	X	–	–	–	X	–	–	–	–	–	R
28	0	0	0	0	0	S	–	X	–	X	D									
29	0	0	0	0	0	0	0	0	0	0	0	0	L	X	X	X	–	–	–	X
30	0	0	0	0	0	0	0	0	0	0	0	0	L	X	–	–	–	–	R	R, X
Total Cracked-Cumulative	1	3	4	6	6	8	9	10	14	16	16	18	20	22	23	24	25	25	25	25

Key to symbols:
L = Crack in lip.
N = Crack in neck.
S = Crack in side.
R = Crack in bottom rim.
B = Crack in bottom.

0 = No cracks.
X = Crack extended.
– = No change.
D = Discarded bottle.

TABLE 3

Thermal shock cracking of new quart bottles (Lot B) during ten successive shocks at 80° F. differential

Bottle No.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	L, N	X	D							
6	L	L, X, N	–	–	–	X	–	R, D		
7	0	0	0	0	0	R	–	–	–	–
8	0	L	N	X	–	X	X	–	–	–
9	L, N	–	X	R, D						
10	0	0	L	–	–	–	–	–	R, D	
11	0	0	0	0	L	–	–	–	–	–
12	0	0	0	0	0	0	0	0	0	0
13	0	L	X	X	–	–	–	–	S, D	
14	0	L, N	X	R	D					
15	0	L, S	D							
16	0	0	0	0	0	0	L	–	–	–
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	L	X	X	–	–	–
19	0	0	0	0	0	0	0	0	0	0
20	L	–	–	–	–	–	–	–	–	–
Total Cracked-Cumulative	4	8	9	9	11	12	13	13	13	13

Key to symbols:

L = Crack in lip.
N = Crack in neck.
S = Crack in side.
R = Crack in bottom rim.
B = Crack in bottom.

0 = No cracks.
X = Crack extended.
– = No change.
D = Discarded bottle.

III. THERMAL SHOCK CRACKING OF BOTTLES DURING WASHING

A plant experiment was made in which approximately seven gross of new quart bottles of one make were washed in a triple tank, 16 pocket-wide Meyer-Dumore washer, on each of 15 consecutive days. After the first time through, the whole lot was sampled at the discharge end by removing 2 bottles from every row of 16. These were thermal shock tested in the laboratory for comparison and are discussed under Part I (Lot B). The remainder of the bottles, numbering 868, were allowed to run to the fillers where they were loaded into new wood-post cases and subsequently moved by conveyors and 4 wheel trucks to the loading end of the washer. There

TABLE 4

Data on washer experiment

Washing No.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	Avg.
Temp. (°F.) of:																
Prerinse	83	83	87	83	88	90	83	83	79	93	81	78	95	95	82	85.5
Tank No. 1	117	118	118	117	114	116	121	115	115	114	113	119	119	124	116	117.1
Tank No. 2	147	148	144	144	136	145	148	133	135	139	139	147	134	145	153	142.4
Tank No. 3	135	127	124	124	130	127	127	125	118	126	122	138	121	127	129	126.6
Outside brush spray	90	82	82	96	85	80	79	95	98	101	98	95	96	79	98	90.2
Inside spray	91	91	83	77	87	87	86	96	81	90	88	85	81	92	83	86.5
Inside brush spray	91	91	83	77	87	87	86	96	81	90	88	85	81	92	83	86.5
City water spray	60	60	60	60	61	61	61	62	62	63	63	62	62	62	64	61.6
Chlorine water spray	63	63	63	63	64	64	64	65	65	65	65	65	65	65	67	64.6
Stops during washing in minutes	0	0	12	0	3	0	0	0	0	6	0	2	0	0	0	
Thermal cracks— Cumulative per cent	1.3	1.8	2.5	2.5	2.9	2.9	3.0	3.1	3.1	3.5	3.5	3.7	3.8	3.9	3.9	

they were individually examined under a 150 watt daylight lamp and all thermal and impact damages were noted. This individual examination was made after each washing. During the washings, temperatures were taken with accurate thermometers at the washer and all stops were noted. When the thermal shock cracks were very fine or just starting they were allowed to remain in the test in order to observe the further development of the cracks. Those with large cracks and impact shock defects were removed after each examination. Account was taken of these in the calculation of the cumulative percentage cracked by thermal shock.

The pertinent data collected in this experiment are shown in Table 4 in comparison with the cumulative percentage of bottles cracked by thermal shock. A good correlation was found between the stopping of the machine and thermal shock cracking. A satisfactory explanation of this relation has not yet been found, but its importance must be stressed. The thermal differential of the various shocks encountered by the bottles during the washing experiment are shown in Table 5. The greatest thermal

TABLE 5

Thermal differentials of shocks in washer during experiment

Location of shocks	Thermal differential in °F.		
	Maximum	Minimum	Average
Prerinse to Tank No. 1	+41	+21	+21.6
Tank No. 1 to Tank No. 2	+37	+21	+25.3
Tank No. 2 to Tank No. 3	−24	− 6	−15.8
Tank No. 3 to outside brush	−48	−20	−36.4
Outside brush jet to inside jet	−19	+ 1	− 3.7
Inside jet to inside brush jet	0	0	0.0
Inside brush jet to city water jet	−34	−17	−24.9
City water jet to chlorine water jet	+ 3	+ 3	+ 3.0

Note: Prerinse jet sprays inside of bottle; Tanks No. 1, 2, and 3 submerge bottles; city water jet sprays inside; and chlorine water jet sprays inside.

differential occurred at the outside brush spray. In the washings where cracking was greatest this differential was around 42°F. to 45°F.; although in one washing with high crackage (10th), this differential was only 25°F. At the outside brushes the bottles are pushed up between two rotating fiber brushes which are being continually sprayed with water at the indicated temperature. This is an outside-surface shock as contrasted to the double surface shocks in the laboratory tests. Preliminary tests in the laboratory have shown that when bottles are tested with the shock on the outside, *i.e.*, hot empty bottles immersed in cold water just up to the lip, a 10°F. lower differential has about the same effect as when the same bottles are tested by the double-surface shock. The failure of this type of test, however, to accurately shock the lip region has already been suggested.

SUMMARY

1. The use of thermal shock tests is discussed and a suitable test for milk bottles is described.

2. The percentage of bottles cracked (up to 50%) as a function of the thermal differential was determined on two lots of bottles.

3. Repeated thermal shocking of bottles at a given temperature differential in laboratory tests, and repeated washings of bottles from the same lot in a commercial washer, both resulted in continual cracking with successive shocks.

4. Washings during which the machine stopped, resulted in more thermal shock cracking than washings during which the machine ran continuously.

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NUTRIENTS FOR LACTATION, WORKING MAINTENANCE, AND GAIN IN LIVE WEIGHT IN AMERICAN DAIRY COWS

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This note supplements a previous paper (1) concerned with the evaluation of the working maintenance exponent, c, in the equation, $DN'' = bW^c$, notation[1] as before. A different method of mathematical analysis is applied to the same experimental data, as follows.

METHOD OF ANALYSIS, ALL DATA

Distinction is made, as before, according to sign of ΔW, that is, whether the cow gained ($+\Delta W$) or lost ($-\Delta W$) in live weight, on the average, during the experimental period. The records are arranged in increasing order by W, and divided into groups by successive 10's. Each group of records so formed is fitted with the equation,

$$DN = aFCM + K + d\Delta W \quad \text{(1)}$$

by use of the normal equations:

$$(n)K + (\Sigma FCM)a + (\Sigma \Delta W)d = \Sigma DN.$$
$$(\Sigma FCM)K + (\Sigma FCM^2)a + (\Sigma FCM\Delta W)d = \Sigma FCMDN.$$
$$(\Sigma \Delta W)K + (\Sigma FCM\Delta W)a + [\Sigma(\Delta W)^2]d = \Sigma \Delta WDN.$$

Each K is taken to represent DN'', or bW^c, for its group, and W is taken to be the average live weight shown by the 10 records of its group. The K's and W's thus derived are fitted with the equation, $K = bW^c$, by use of the weighted[2] normal equations:

$$(\Sigma K^2)\log b + (\Sigma K^2 \log W)c = \Sigma K^2 \log K.$$
$$(\Sigma K^2 \log W)\log b + [\Sigma K^2 (\log W)^2]c = \Sigma K^2 \log W \log K.$$

Finally, for a given set of K's and W's, a is taken to be the average of the a's in that set; and similarly for d. We thus arrive at a solution of the equation,

$$DN = aFCM + bW^c + d\Delta W \quad \text{(2)}.$$

Received for publication March 23, 1938.

[1] Symbols are used to apply to each experimental period for each cow, as follows:

DN = digestible nutrients intake, pounds per day
DN' = digestible nutrients apportioned to lactation, pounds
DN'' = digestible nutrients apportioned to maintenance, pounds per day
DN''' = digestible nutrients apportioned to gain in weight, pounds
FCM = milk-energy yield, pounds of 4 per cent milk per day
W = average live weight, pounds
ΔW = average gain in live weight, pounds per day
n = number of cows or records
D = observed DN − calculated DN.

[2] Dr. W. Edwards Deming, U. S. Department of Agriculture, has very kindly called my attention to the necessity of weighting the normal equations by K^2. Neither the weighted nor unweighted normal equations give a true least-squares fit for $K = bW^c$ when the observed K's are so highly irregular as they are in the present data.

In equation (2), a is the pounds of digestible nutrients per pound of FCM apportioned to lactation; b is the pounds of digestible nutrients per day per pound of live weight raised to the power, c, apportioned to working maintenance; and d is the pounds of digestible nutrients per pounds of gain in live weight, apportioned to gain in live weight. Or, in symbols, $DN' = aFCM$, $DN'' = bW^c$, $DN''' = d\Delta W$, and $DN = DN' + DN'' + DN'''$.

A positive d means that the method apportions a consumption of nutrients for gain in live weight or a release of nutrients for loss in live weight. A negative d means a consumption of nutrients for loss in weight and a release of nutrients for gain in weight. While a negative d is opposed to logical expectation, it is not at all contrary to a mathematical balancing of the values to which equation (1) is fitted, because of normal irregularities and errors in the observations.

TABLE 1

Digestible nutrients apportioned to lactation, working maintenance, and live-weight gain
Records of Guernsey, Holstein and Jersey cows from various experiment station sources, in groups of 10.
(See footnote, page 585, for explanation of symbols.)

Group No.	Sign of ΔW	n	Live-weight Limits, lbs.	W	$DN' = aFCM$ a	$DN'' = bW^c$ 1000 b	$DN''' = d\Delta W$ d
1	−	10	634– 783	732	.2385	10.57	1.82
2	+	10	735– 790	770	.2732	9.77	1.63
3	−	10	792– 824	808	.3003	7.94	2.30
4	+	10	793– 843	819	.4256	4.64	12.38
5	−	10	833– 858	846	.2836	8.73	1.84
6	+	10	846– 885	864	.1507	13.99	−.30
7	−	11	859– 898	878	.3089	9.01	6.70
8	+	10	887– 925	906	.2812	8.30	3.58
9	−	10	902– 978	928	.2277	11.26	.28
10	+	10	929– 996	970	.3219	8.99	1.35
11	+	10	1008–1072	1046	.3172	7.87	2.80
12	+	10	1073–1120	1096	.2927	9.02	1.53
13	−	10	985–1195	1105	.3031	8.27	−2.65
14	+	10	1128–1172	1152	.2519	10.58	−1.15
15	+	12	1175–1203	1188	.3290	8.06	.10
16	+	10	1207–1232	1220	.3170	7.32	1.34
17	−	10	1203–1273	1242	.4083	4.74	−2.88
18	+	10	1239–1267	1251	.2702	8.59	2.76
19	+	10	1271–1287	1278	.2434	9.22	1.37
20	+	10	1288–1301	1296	.0906	13.34	.79
21	+	10	1305–1323	1314	.3185	6.86	1.83
22	+	10	1327–1341	1335	.2776	7.80	3.33
23	+	10	1341–1382	1363	.1846	10.04	.71
24	−	10	1331–1500	1395	.2712	8.27	1.82
25	+	10	1384–1453	1402	.1815	10.72	−2.50